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Foreword

Historically, ships have played a significant role in the global transmission of infectious disease. Some of the earliest recorded evidence of attempts to control human disease transmission via ships date to the fourteenth century when ports denied access to ships suspected of carrying plague. In the nineteenth century the spread of cholera pandemics was thought to be facilitated by merchant shipping. Most recently, a World Health Organization (WHO) review identified over 100 disease outbreaks associated with ships between 1970 and 2000.

In 2000, 10 million people travelled on cruise ships. This figure is expected to double by the year 2010. It is estimated that 1.2 million seafarers are employed on general cargo vessels. Naval vessels also carry considerable numbers of crew, sometimes over 5,000 per ship. Ferries are ubiquitous around the world in port cities and at some river crossings and are used by many people on a daily basis.

Because of its international nature, international regulations relating to sanitary aspects of ship transport have been in place for over half a century. The International Sanitary Regulations of 1951 were replaced by the International Health Regulations (IHR) adopted by the World Health Organization (WHO) in 1969. The IHR were revised at the Fifty-eighth World Health Assembly, 23 May 2005.

The WHO Guide to Ship Sanitation has become the official global reference on health requirements for ship construction and operation. Its purpose is to standardize the sanitary measures taken in ships, to safeguard the health of travellers and workers and to prevent the spread of infection from one country to another.

The Guide was first published in 1967 and amended in 1987. This revised 3rd edition of the Guide has been prepared to reflect the changes in construction, design and size of ships since the 1960s and the existence of new diseases (e.g. Legionnaires' disease) that were not foreseen when the 1967 Guide was published.

In revising the Guide, meetings were held in Miami, United States on 3-4 October 2001 and in Vancouver, Canada on 8-10 October 2002 to discuss and recommend the proposed contents. Participants represented the ship building industry, cruise ship operators, seafarers associations, collaborating member states for the IHR, Port State Control, Port Health Authorities and other regulatory agencies. Experts from Australia, Brazil, Canada, Egypt, Finland, India, Morocco, the Netherlands, Norway, Russia, South Africa, Thailand, the United Kingdom and the United States were involved in the revision project. The Guide to Ship Sanitation and Ship Medical Guide are companion volumes oriented towards preventive and curative health on board ships.

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Glossary

Acceptable non-rat-proof material	A material the surface of which is resistant to the gnawing of rats when the edges exposed to gnawing (the "gnawing-edges") are flashed, but which is subject to penetration by rats if the gnawing-edges are not so treated.
Accessible	Capable of being exposed for cleaning and inspection with the use of simple tools such as a screwdriver, pliers, or an open-end wrench.
Air break	A piping arrangement in which a drain from a fixture, appliance, or device discharges indirectly into another fixture, receptacle, or interceptor at a point below the flood-level rim.
Air gap	The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle or receiving fixture. The air gap would typically be at least twice the diameter of the supply pipe or faucet or at least 25 mm (1 in).
Backflow	The flow of water or other liquids, mixtures, or substances into the distribution pipes of a potable supply of water from any source or sources other than the potable water supply. Back-siphonage is one form of backflow.
Backflow preventer	An approved backflow prevention plumbing device that would typically be used on potable water distribution lines where there is a direct connection or a potential connection between the potable water distribution system and other liquids, mixtures, or substances from any source other than the potable water supply. Some devices are designed for use under continuous water pressure, whereas others are non-pressure types.
Backflow, check, or non-return valve	A mechanical device installed in a water or waste line to prevent the reversal of flow under conditions of back pressure. In the check-valve type, the flap would swing into a recess when the line is flowing full in order to preclude obstructing the flow.
Back-siphonage	The backward flow of used, contaminated, or polluted water from a plumbing fixture or vessel or other source into a water-supply pipe as a result of negative pressure in the pipe.
Black water	Waste from toilets, urinals, medical sinks, and other similar facilities.
Blast chiller	A unit specifically designed for rapid intermediate chilling of food products to 21ºC (70ºF or 294ºK) within 2 hours and 5ºC (41ºF or 278ºK) within an additional 4 hours.
Child activity facility	Facility for child-related activities where children do not require assistance using toilet facilities and may be old enough to come and go on

	their own.
Child care facility	Facility for child-related activities where children are not yet out of diapers or require supervision using the toilet facilities, and are cared for by vessel staff.
Child size toilet	Toilet of appropriate height and having a seat size appropriate for the age and average size of the children that will use the toilet.
Closed joints, seams and crevices	Those where the materials used in fabrication of the equipment join or fit together snugly. Suitable filling materials may be used to effect a proper closure. (See also sealed spaces).
Closed-type construction	Construction in which places that are not easily inspectable are closed by means of dependable rat-proofing.
Corrosion-resistant	Capable of maintaining original surface characteristics under prolonged influence of the use environment, including the expected food contact and the normal use of cleaning compounds and sanitizing solutions. Corrosion-resistant materials must be non-toxic.
Coved	A concave surface, moulding, or other design that eliminates the usual angles of ninety degrees or less.
Cross-connection	Any unprotected actual or potential connection or structural arrangement between a public or a consumer's potable water system and any other source or system through which it is possible to introduce into any part of the potable system any used water, industrial fluid, gas, or substance other than the intended potable water with which the system is supplied. Bypass arrangements, jumper connection, removable section, swivel or change-over devices and other temporary or permanent devices which or because of which backflow can occur are considered to be cross-connections.
Deck sink	A sink recessed into the deck, usually located at tilting kettles and pans.
Direct splash surfaces	Areas adjacent to food contact surfaces that are subject to splash, drainage, or drippage onto food contact surfaces.
Durable materials or constructions	Those that are able to withstand normal use and abuse.
Easily cleanable	Fabricated with a material, finish, and design that allows for easy and thorough cleaning with normal cleaning methods and materials.
Easily inspectable	Places which are open to view from the deck or conveniently accessible for inspection.
Flashing	The capping or covering of corners, boundaries and other exposed edges of acceptable non-rat-proof material in rat-proof areas. The flashing strip would typically be of rat-proof material, wide enough to cover the

	gnawing-edges adequately and firmly fastened.
Floor sink	See deck sink.
Food contact surfaces	Surfaces of equipment and utensils with which food normally comes in contact and surfaces from which food may drain, drip, or splash back onto surfaces normally in contact with food, this includes the areas of ice machines over the ice chute to the ice bins. (See also non-food contact surfaces).
Food display areas	Any area where food is displayed for consumption by passengers and/or crew.
Food handling areas	Any area where food is stored, processed, prepared, or served.
Food preparation areas	Any area where food is processed, cooked, or prepared for service.
Food service areas	Any area where food is presented to passengers or crew members (excluding individual cabin service).
Food storage areas	Any area where food or food products are stored.
Food transport areas	Any area through which unprepared or prepared food is transported during food preparation, storage, and service operations (excluding individual cabin service).
Grey water	All water including drainage from galleys, dishwashers, showers, laundries, and bath and washbasin drains. It does not include black water or bilge water from the machinery spaces.
Halogenation	In this context, halogenation refers to disinfection using halogen disinfectants, such as chlorine, bromine or iodine, to treat recreational water or potable water to reduce the concentration of pathogenic microorganisms.
Indirect splash surfaces	Areas adjacent to food contact surfaces that are subject to splash, drainage, drippage, condensation, or spillage from food preparation and storage.
Keel laying	The date at which construction identifiable with a specific ship begins and when assembly of that ship comprises at least 50 tons or one per cent of the estimated mass of all structural material, whichever is less.
Maximum opening	The largest opening through which a rat cannot pass, applicable to both rat-proof and rat-tight areas. Regardless of the shape of the opening, it would normally be 1.25 cm (0.5 in) or less in the minimum dimension.
Non-absorbent materials	Those whose surface is resistant to the penetration of moisture.
Non-food contact	All exposed surfaces, other than food contact or splash contact surfaces,

surfaces	of equipment located in food storage, preparation and service areas.
Non-potable fresh water	Fresh water that may not be halogenated but is intended for use in technical and other areas where potable water is not required (e.g., laundries, engine room, toilets, and waste-treatment areas and for washing decks in areas other than the vessel's hospital, food service, preparation, or storage areas).
Non-toxic materials	Those that, when used in food processing areas, do not introduce harmful or injurious ingredients or substances into the food.
Open-type construction	Construction in which partially enclosed places are open to view for inspection and accessible for maintenance.
Portable	A description of equipment that is readily removable or mounted on casters, gliders, or rollers; provided with a mechanical means so that it can be tilted safely for cleaning; or readily movable by one person.
Potable water	Fresh water that is intended for drinking, washing, bathing, or showering; for use in fresh water recreational water environments; for use in the vessel's hospital; for handling, preparing, or cooking food; and for cleaning food storage and preparation areas, utensils, and equipment. Potable water, as defined by the WHO *Guidelines for Drinking-water Quality 2004* does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.
Potable water tanks	All tanks in which potable water is stored from bunkering and production for distribution and use as potable water.
Rat proof material	A material the surface and edges of which are resistant to the gnawing of rats.
Rat-proof area	An area that is completely isolated from other areas by means of rat-proof material.
Rat-tight area	An area bounded by material that contains no hole large enough for the passage of rats, although not necessarily rat-proof. Rat-tightness is sufficient only in more frequented areas, where rats cannot gnaw undisturbed.
Readily accessible	Exposed or capable of being exposed for cleaning or inspection without the use of tools.
Readily removable	Capable of being detached from the main unit without the use of tools.
Removable	Capable of being detached from the main unit with the use of simple tools such as a screwdriver, pliers, or an open end wrench.
Safe material	An article manufactured from, or composed of materials that may not reasonably be expected to result, directly or indirectly, in their becoming

	a component of any food or otherwise affecting the characteristics of any food.
Scupper	A conduit or collection basin that channels water runoff to a drain.
Sealant	Material used to fill seams to prevent the entry or leakage of liquid or moisture.
Sealed seam	A seam that has no openings that would permit the entry of soil or liquid seepage.
Sealed spaces	Those that have been effectively closed, all joints, seams and crevices having been made impervious to insects, rodents, seepage, infiltration and food fragments or other debris.
Seam	An open juncture between two similar or dissimilar materials. Continuously welded junctures, ground and polished smooth, are not considered seams.
Sewage	Any liquid waste that contains animal or vegetable matter in suspension or solution, including liquids that contain chemicals in solution.
Smooth	Surfaces having the following finishes (Vessel sanitation program, 2001): • A food contact surface that is free of pits and inclusions with a cleanability equal to or exceeding that of a No. 3 finish (100 grit) on stainless steel. • A non-food contact surface of equipment that is equal to commercial grade hot-rolled steel and is free of visible scale. • A deck, bulkhead, or deckhead that has an even or level surface with no roughness or projections that render it difficult to clean.
Smooth metal surfaces	• Corrosion-resistant alloys would typically have at least a No. 4 mill finish, properly applied. • Cast iron, cast and forged steel and cast nickel alloys, in the food area, would typically have a surface roughness not exceeding American Standard No. 125 (or equivalent). • Galvanized metal surfaces, where acceptable, would typically have the smoothness of good-quality commercial hot dip. • Other metals would typically be at least as smooth as commercial-grade rolled sheet steel and free of loose scale.
Splash contact surfaces	Surfaces that are subject to routine splash, spillage or other soiling during normal use.
Technical water	Fresh water not intended for:

	• drinking, washing, bathing, or showering; • use in the vessel's hospital; • handling, preparing, or cooking food; and • cleaning food storage and preparation areas, utensils, and equipment.
Temperature Measuring Devices (TMDs)	Ambient air, and water temperature measuring devices that are scaled in Celsius or dually scaled in Celsius and Fahrenheit shall be designed to be easily readable and accurate to ± 1.5ºC (3ºF).
Transportation corridors	Any area through which unprepared or prepared food is transported during food preparation, storage, and service operations excluding provision areas, and passenger corridors
Utility sink	Any sink located in a food service area not used for hand washing and/or ware washing.

1 Introduction

1.1 Ships and Public Health

Over one hundred outbreaks of infectious diseases were reported that were associated with ships between 1970 and 2000 (WHO 2001). Reported outbreaks included legionellosis, typhoid fever, salmonellosis, viral gastroenteritis, enterotoxigenic *E coli* infection, shigellosis, cryptosporidiosis and trichinosis. Naval, cargo and cruise vessels were all affected, often with serious operational and financial consequences.

These reported outbreaks represent just a small proportion of the total disease burden attributable to ship-acquired disease. For every notified and reported case listed in outbreak reports, there are likely to be orders of magnitude more cases that go unreported.

Ships can have significance to public health beyond just their role in ship-acquired infection. For example, ships can transport infected humans and other vectors, such as mosquitoes and rats, between ports and, therefore, act as a means of national and international disease transfer.

If proper control measures are not in place, ships are particularly prone to disease outbreaks. Ships are isolated communities with crowded living accommodation, shared sanitary facilities and common food and water supplies. Such conditions are favourable to the spread of infectious diseases. The inevitable publicity that comes along with a disease outbreak aboard ship can seriously impact financially on the ship owners and those relying on use of the ship for transport or leisure.

Becoming ill aboard ship can be particularly dangerous because the ship may be isolated from medical centres. Furthermore, once an outbreak has been reported aboard ship it may not be permitted to dock. It is estimated that 1.2 million seafarers are employed on general cargo vessels. Many spend months at sea, sometimes in remote regions of the world. Cargo ships on long voyages are isolated communities. Good sanitation conditions on vessels are crucial both to the health of seafarers and to the shipping industry's ability to attract and retain competent employees.

Historically ships have played an important role in transmitting infectious diseases around the world. The spread of cholera pandemics in the nineteenth century was thought to be linked to trade routes and facilitated by merchant shipping. Efforts to control human disease on ships, can be traced back to the Middle Ages when, in 1377, Venice and Rhodes denied access to ships carrying passengers infected with the plague and the term "quarantine" was coined. On arrival travellers were detained in isolation for 40 days before they were allowed to proceed to their final destination. Overcrowding on ships, filth and lack of personal hygiene were often associated with epidemics of typhus fever. Preventive measures, such as quarantine, delousing, and maintaining personal cleanliness by use of soap, were gradually adopted, and the incidence of typhus decreased.

By taking sensible preventative control measures it is possible to protect passengers, crew and the public at large from disease transmission related to ships. To the extent possible, control strategies should be targeted to minimising contamination at source. From a public health perspective, the focus should be proactive and preventative rather than reactive and curative. For example:

- The design and construction of the ship should be as failsafe as possible with respect to maintaining a sanitary environment.
- The food, water and materials taken aboard ship should be as safe as possible in the first place.
- Crew should be well trained in ship sanitation and have all the required equipment, facilities, materials and capacity to readily maintain a sanitary environment aboard ship.

1.2 International Health Regulations

The International Sanitary Regulations were developed in 1951 to prevent the spread of six infectious diseases – cholera, plague, yellow fever, smallpox, typhus and relapsing fever. These regulations were revised and renamed the International Health Regulations (IHR) in 1969.

The purpose of the International Health Regulations is, and remains, as being: "to provide security against the international spread of disease while avoiding unnecessary interference with international traffic".

The IHR were amended in 1973 and 1981. The diseases subject to these regulations were reduced to three: plague, yellow fever and cholera. In 1995 the World Health Assembly called for the regulations to be revised. The IHR were revised and presented to the Fifty-eighth World Health Assembly on 23 May 2005 (WHO 2005).

The IHR applies to world traffic: ships, aircraft, other conveyances, the travellers and cargos, and their primary considerations are for arrivals. Ship and Aircraft are discussed specifically in their own *Guide to Ship Sanitation* and *Guide to Hygiene and Sanitation in Aircraft* respectively. The Guides provide a summary of the health basis behind the IHR and help to bridge the gap between the regulation, as a legal document, and the practical aspects of implementation of appropriate practices.

1.3 WHO Guide to Ship Sanitation

In 1967, the World Health Organization published the *Guide to Ship Sanitation* (The Guide) which was subjected to minor amendments in 1987. In the past The Guide was directly referenced in the IHR (Article 14) and its purpose was to standardise the sanitary measures taken in relation to ships to safeguard the health of travellers and to prevent the spread of infection from one country to another.

The 1967 Guide was based on the results of a survey of 103 countries and represented a synthesis of best national practice at the time. It covered potable water supply, swimming pool safety, waste disposal, food safety and vermin control. Before publication it was circulated to the International Labour Organization (ILO) and a number of other international agencies for comment. The Guide supplemented the requirements of the IHR 1981 and was the official global reference for health requirements for ship construction and operation.

Since 1967 a number of specific guidance documents, conventions and regulations have evolved that provide full accounts of the design and operational detail relating to ships and many take sanitation into consideration. To some extent these have made the purpose of the original Guide outdated and the purpose of this revised Guide is different. The Guide is no longer explicitly referenced in the current draft of the revised IHR (WHO 2005).

The primary aim of the revised *Guide to Ship Sanitation* is to present the public health significance of ships in terms of disease and to highlight the importance of applying appropriate control measures. The guide is intended to be used as a basis for the development of national approaches to controlling the hazards that may be encountered on ships, as well as providing a framework for policy making and local decision making. The guide may also be used as reference material for regulators, ship operators and ship builders, as well as a checklist for understanding and assessing the potential health impacts of projects involving the design of ships.

1.4 Structure of the Guide

The Guide is structured into three sections and 12 chapters as follows:

General Introduction, setting the GSS in their legal context, considering the International Health Regulations and describing the relationship to other documents and regulations and standards:

Chapter 1. Introduction.

Health evidence chapters, divided according to exposure and dissemination pathways. Each chapter provides an overview of the health significance of ships with respect to the relevant pathway and outlines the strategies that can be used to control disease transmission:

Chapter 2. Water Safety.

Chapter 3. Food Safety.

Chapter 4. Recreational water environments.

Chapter 5. Ballast Water and Waste Management and Disposal.

Chapter 6. Legionnaires' Disease.

Chapter 7. Persistent Infectious Agents.

Chapter 8. Disease Vectors.

User-targeted chapters, divided according to the main categories of those responsible for ship sanitation. Each chapter identifies responsibilities and provides examples of practices that can control risks. Each chapter is further subdivided into exposure pathway sections:

Chapter 9. Roles and Responsibilities.

Chapter 10. Designer/Constructor.

Chapter 11. Owner/Operator.

Chapter 12. Master/Crew.

Chapter 13. Port Authority.

Chapter 14. Port Health Authority.

1.5 Development of the Guide

The Guide has been developed through an iterative series of drafting and peer review steps. This has included international workshops, the first being held in Miami, Florida, 1-3 October 2001 and the second in Vancouver, Canada, 8-10 October 2002. Draft material was presented and comments were captured and collated to reach a consensus on structure and content. Finally, a series of international consultations were held and the current draft of the Guide has been prepared for these consultations and for the open public consultations.

2 Water Safety

2.1 Health effects

Improperly managed water is an established infectious disease transmission route on ships. The importance of water was illustrated in the review of over 100 outbreaks associated with ships undertaken by WHO (2001) in which one fifth were attributed to a waterborne route. This is probably an underestimate since over one third of the 100 reviewed outbreaks could not be associated with any specific exposure route so some may have been waterborne. Furthermore, water may be a source of index cases of disease which might then be transmitted via other routes.

Most waterborne outbreaks involved ingestion of water that was contaminated with pathogens derived from human or animal excreta. In addition, chemical outbreaks of water poisoning have also occurred on ships, although chemical incidents are much less commonly reported than microbial. Contamination can arise on ship or from water uplifted at port.

Some of the causal hazardous agents associated with waterborne disease outbreaks associated with ships are listed in Table 2-1 (WHO 2001). Note that in some waterborne outbreaks the causative agent was not identified.

Some ports do not supply a safe source of water and contaminated loaded water was associated with a number of outbreaks aboard ship including outbreaks due to ETEC, *Giardia lamblia* and *Cryptosporidium*.

Table 2-1 Agents associated with waterborne disease outbreaks associated on ships

Pathogens/ toxins	**Waterborne outbreaks 1970- 2000**
Enterotoxigenic *Escherichia coli* (ETEC)	5
Norovirus	5
Vibrio spp	2
Salmonella typhi	1
Salmonella spp (non typhi)	1
Shigella spp	1
Cryptosporidium sp	1
Giardia lamblia	1
Chemical poisoning	1
Unknown agent	4

Source: WHO, 2001

2.2 Standards and guidelines

Reference should be made to the current edition of the WHO Guidelines for Drinking-water Quality 2004 (WHO 2004a) (GDWQ) (http://www.who.int/en/) which identifies the broad spectrum of contaminants from microorganisms, inorganic and synthetic organic chemicals, disinfection by products and radionuclides that can reach hazardous concentrations in potable water supplies and describes systematic approaches to risk management. As a general definition, safe drinking-water, as defined by these Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.

2.3 Risk factors

Outbreaks were associated with contaminated bunkered water, cross-connections between potable and non-potable water, improper loading procedures, poor design and construction of potable water storage tanks and inadequate disinfection.

Space is often very limited on ships. Potable water systems are likely to be physically close to hazardous substances such as sewage or waste streams. This physical proximity increases the chances of cross-connections occurring.

In considering the evidence from outbreaks, the presence of pathogens that are generally only transmitted to humans from other human sources (viral pathogens and *Shigella* spp) indicates that sewage is one of the more common sources of the pathogens that cause waterborne disease outbreaks on ships.

2.4 Control strategies

Waterborne outbreaks have been associated with loading poor quality water. Therefore, the first waterborne disease prevention strategy should be to load ships with the safest water available at port. To support this objective, ports should make good quality potable water available to ships. Another common cause of waterborne outbreaks is cross-contamination from sewage aboard ship. Rigorous cross-connection control programs should be practiced both during loading and in storing, distributing, treating and using potable water.

It is important to note that although treatment of water can reduce contamination levels, there are limitations. Treatment systems can fail and even when operational are only effective against a limited range of contaminants. Furthermore, water can become recontaminated following treatment. Therefore, reliance should not be placed on treatment alone and multiple barriers should be actively maintained including:

- loading the safest possible water in the first place;
- preventing contamination during storage;
- treating to remove some forms of contamination that might have arisen; and
- storing and using water in ways that prevent post-treatment contamination.

A detailed discussion of the types of control measures that can be applied to prevent waterborne disease outbreaks aboard ship is given in chapters 10 to 14. Attention should be given to the contemporary use of a preventative, multiple barrier risk management approach to drinking-water safety termed the ‘Water Safety Plan’ (WHO 2004a; Davison et al 2005).

3 Food Safety

3.1 Health effects

Significant levels of foodborne disease transmission on ships have been reported. The WHO (2001) review of over 100 outbreaks associated with ships found that two fifths of the outbreaks reported were attributed to a foodborne route. Since more than one third of the reviewed outbreaks could not be associated with any specific exposure route the true contribution from foodborne transmission to the total may be significantly higher. The WHO (2001) review provided important information on examples of, and possible causes of, foodborne disease and the cited incidents are referred to throughout this chapter.

Importantly, the majority of reported foodborne disease outbreaks were caused by pathogenic bacteria such as *Salmonella* spp, *Shigella* spp and *Vibrio* spp. The symptoms of bacterial infections can be more severe and prolonged than are typically observed with the more common viral diseases or from *Cryptosporidium* infection. This implies an enhanced morbidity burden due to foodborne disease that further emphasises the significance of this exposure route.

Foodborne disease is often referred to generally as “food poisoning” which has in turn been defined by WHO as “any disease of an infectious or toxic nature caused by or thought to be caused by the consumption of food”. This definition includes all illness regardless of the presenting symptoms and signs thought to have been caused by food. The definition includes acute illnesses characterized by diarrhoea and/or vomiting and illnesses presenting with manifestations not related to the gastrointestinal tract, such as scombrotoxin poisoning, paralytic shellfish poisoning, botulism, and listeriosis. In addition, the definition includes illnesses caused by toxic chemicals but excludes illness due to known allergies and food intolerances. Note that ‘foodborne’ refers to the probable source of the infection, not the nature of the signs and symptoms. Many of the signs and symptoms and many of the diseases that can be foodborne an also be acquired from other causes such as person-to-person and waterborne transmission.

This chapter is focused on foodborne disease and includes disease associated with packaged (bottled) water. The previous chapter (Chapter 2) considered disease associated with the reticulated water supplied aboard ship.

Foodborne biological hazardous agents include bacteria, viruses, fungi and parasites. These organisms are commonly associated with humans and with raw products entering the food preparation site. Many of these microorganisms occur naturally in the environment where food is grown. Therefore, some contamination by these pathogens can be expected in any raw food.

A range of helminthic and protozoan parasites can contaminate food. Many are zoonotic (capable of infecting many species of animals and humans) so meat and poultry can become directly contaminated at source. Some diseases are faecal-oral whilst others are transmitted via consumption of contaminated flesh. Parasitic infections are commonly associated with undercooked meat products or contaminated ready to eat food. Some parasites in products that are intended to be eaten raw, marinated or partially cooked can be killed by effective freezing techniques (the precise conditions appropriate will depend on the nature of both the food and the parasites).

Chemical contaminants in food may be inadvertently added during the growing phase, be naturally occurring or may be added accidentally during processing, for example, by the misuse of cleaning chemicals or pesticides. Examples of naturally occurring chemicals are mycotoxins (e.g. aflatoxin), scombrotoxin (histamine), ciguatoxin, mushroom toxins and shellfish toxins.

Some of the causal hazards associated with foodborne disease outbreaks associated with ships are listed in Table 3-1 (WHO 2001). Note that in some foodborne outbreaks the causative agent may not be identified.

Table 3-1 Agents associated with foodborne disease outbreaks associated with ships

Pathogens/ toxins	**Foodborne outbreaks 1970- 2000 (WHO 2001)**
Enterotoxigenic *Escherichia coli* (ETEC)	4
Invasive *Escherichia coli*	1
Norovirus	10
Vibrio spp	4
Salmonella spp (non typhi)	12
Shigella spp	4
Staphylococcus aureus	2
Clostridium perfringens	1
Cyclospora spp	1
Trichinella spiralis	1
Unknown agent	1

3.2 Standards and guidelines

The Codex Alimentarius Commission (CAC) implements the joint FAO/WHO Food Standards Programme, the purpose of which is to protect the health of consumers and to ensure fair practices in the food trade. The Codex Alimentarius is a collection of internationally adopted food standards presented in a uniform manner. It also includes provisions of an advisory nature in the form of codes of practice, guidelines and other recommended measures to assist in achieving the purposes of the Codex Alimentarius (CAC 1995; 1997a, b; 1999; 2003). The CAC guidance provides important information on basic food safety which will be referred to throughout this chapter.

The International Labour Organization (ILO 1976) has developed labour standards that include consideration of food and catering requirements and competencies for merchant ships.

3.3 Risk factors

Factors contributing to foodborne outbreaks aboard ship have included inadequate temperature control, infected food handlers, cross contamination, inadequate heat treatment, contaminated raw ingredients and use of seawater in the galley.

Bacteria and fungi present the greatest risk. Firstly, both raw and cooked food can provide a fertile medium and support rapid growth of these organisms. Food can become re-contaminated after it has cooled such that cooked food is not necessarily safe. Secondly, there are toxins of fungal and bacterial origin that are relatively heat stable and can remain at hazardous levels even after cooking. Therefore, the contamination levels in raw food should be minimised even if it is to be cooked.

Unlike bacteria and fungi, human-pathogenic viruses are unable to reproduce outside a living cell. In general, they cannot replicate in food, and can only be carried by it. Furthermore, most foodborne viruses affecting humans are limited to human hosts. This make contamination by the unclean hands of infected food handlers or cross-contamination from human faecal contamination the prime risk factors.

The presence of non-potable water on ship can also present additional risks to foods. For example, outbreaks of *V. parahaemolyticus* gastrointestinal illness have been associated with use of seawater in the galley. Recommendations for preventing subsequent outbreaks emphasized that only potable water should be supplied to the galley and food should not be held at ambient temperature for extended periods.

The pressure on space and facilities aboard ship can lead to a lack of adequate facilities and equipment and this can be a contributory factor in causing disease. For example, in an outbreak of multiple antibiotic resistant *Shigella flexneri* 4a the spread of infection by an infected food handler may have been facilitated by limited availability of toilet facilities for the galley crew. Conveniently located hand washing and toilet facilities are a prerequisite for hygienic handling of food.

3.4 Control strategies

Foodborne outbreaks have been associated with taking on board contaminated food. Therefore, the first foodborne disease prevention strategy should be to load ships with the safest food available. Another common cause of foodborne outbreaks is contamination of food by infected food handlers aboard ship. Rigorous safe food handling programs should be practiced during loading and in storing, preparing and serving food.

Most of the microorganisms that cause foodborne disease are killed or inactivated by normal cooking processes. However, although cooking of food can control some contaminants, there are limitations. Cooking processes are not always carried out effectively and in any case some hazardous agents, such as some toxins, can persist through cooking processes. Furthermore, food can become recontaminated following cooking by both passengers, crew and vectors such as rodents and insects. Therefore, reliance should not be placed on cooking processes alone and multiple barriers should be actively maintained including:

- loading the safest possible food in the first place;
- preventing contamination during storage;

- cooking and washing to remove some forms of contamination that might have arisen or be naturally present; and
- storing and serving food in ways that prevent post-treatment contamination.

A detailed discussion of the types of control measures that can be applied to prevent foodborne disease outbreaks aboard ship is given in chapters 10 to 14. Attention should be given to the contemporary use of a preventative, multiple barrier risk management approach to food safety termed the ‘Food Safety Plan’ and based around the ‘Hazard Analysis and Critical Control Point’ (HACCP) principles (CAC 2003 and ISO 22000:2005).

4 Recreational water environments

4.1 Health effects

Recreational water environments can present a number of risks to health. The most immediate and severe danger arises from accidental drowning. Another source of harm is the injuries, potentially serious or even fatal, that can arise from slipping and tripping or from becoming snagged in ropes and fences or fittings such as ladders and drains. There have even been cases where swimmers have been thrown clear of the pool onto hard surfaces in heavy seas. In relation to ship sanitation, a number of infectious diseases can be acquired in swimming and spa pools and cause diarrhoea or skin, ear, eye, and upper respiratory infections.

Faecal-oral pathogens have commonly been associated with swimming and spa pools and arise from pathogens entering with sewage or animal faecal contamination or from contamination released directly by infected bathers. One of the most important such pathogens is *Cryptosporidium* which has infectious oocysts that are resistant to even the highest levels of chlorine that are generally used for maintaining residual disinfection in pools. Thousands of cases of swimming-associated cryptosporidiosis have been reported (Lemmon *et al* 1996, CDC 2001a) and public swimming pools can be temporarily shut down as a result. Where water quality and treatment have been inadequate, bacterial infections from *Shigella* (CDC 2001b) and *Escherichia coli* O157:H7 (CDC 1996) have been associated with swimming and spa pools.

Infections of surfaces such as skin and ears have been associated with spa pools where disinfection has been inadequate. These infections arise from opportunistic pathogens that are commonly present in water and soils. The recreational water environment is risky because it can both amplify the concentration of the hazard and facilitate exposure of humans to the hazard. The combination of organic nutrients from humans and the elevated temperatures maintained in some recreational water environments provides particularly suitable environments for some opportunistic pathogens to grow.

Pseudomonas aeruginosa infection has been associated with a number of skin and ear infections arising from immersion in water with inadequate disinfection (Gustafson *et al* 1983, Ratnam *et al* 1986, CDC 2000). Symptoms have included outer ear and ear canal infections ("Swimmer's Ear" or "Otitis Externa") and skin infections such as dermatitis and folliculitis. Where aerosols are generated, the elevated temperature found in some recreational water environments can support *Legionella*, infections from which have caused outbreaks of legionnaire's disease associated with hot tubs, including outbreaks aboard ship discussed in the review by WHO (2001). More recently, mycobacterial infections have been associated with pneumonitis linked to exposure to aerosols from swimming and spa pools (Falkinham 2003).

In managing risk from microbial hazards using disinfectants, other risks can arise. For example, harm can result from excessive disinfectant chemical addition either directly or potentially through disinfection by-products. The disinfection by-products arise when chlorine reacts with organic matter, such as is found in sloughed skin, sweat and urine, and forms organohalide compounds, such as chloroform. Ozone can also react to produce a different set of by-products. These by-product compounds are of uncertain health significance at the low concentrations found but might be weakly associated with certain types of cancer or adverse pregnancy outcomes if consumed in large amounts (WHO 2004a).

4.2 Standards and Guidelines

The Guidelines for Safe Recreational Waters Volume 2 - Swimming Pools and Similar Recreational Water Environments (WHO 2004b) should be referred to as these apply generally to recreational water environments.

4.3 Risk factors

Recreational water environment usage levels are directly related to risk. The more people that recreate, the higher the concentrations of pathogens released, the greater the demand on the disinfection system and the higher the number of people in a position to become infected.

Pools are particularly attractive to children and infants which in turn gives rise to increased risks of contamination and safety. Children and infants are more likely to be infected with enteric pathogens than adults and they are more likely to release faeces into the water, either through smears or through accidental faecal release. Furthermore, children and infants are more likely to swallow pool water than adults. Finally, children and infants are more prone to carelessness and slips, trips and drowning than adults.

Another important risk factor that particularly affects pools on ships is the movement of the ship itself. This movement increases the likelihood of accidents in particular.

The presence of organic matter and elevated temperatures associated with many recreational water environments can provide an environment suitable for the proliferation of opportunistic pathogens that can infect mucous membranes, lungs, skin and wounds. The loss of disinfectant residual in these environments will permit proliferation of such pathogens to unsafe levels.

4.4 Control strategies

Outbreaks associated with recreational water environments have been linked to poor system design. Therefore, the first disease prevention strategy should be to ensure that the design of recreational water environments is adequate given the extent and nature of use as well as the nature of the use environment. Another common cause of outbreaks is improper operation of controls such as allowing recreational water environments to be loaded beyond capacity or engaging in poor operational practices. Design limits should be adhered to and systems should be properly operated at all times.

Treatment systems can reduce contamination levels but these can become overloaded. Therefore, reliance should not be placed on treatment alone and multiple barriers should be actively maintained including:

- filling and topping up recreational water environments with the safest possible water in the first place;
- controlling usage rates to within system design capacity;
- maintaining treatment to control some forms of contamination; and
- taking prompt action to clear the recreational water environment and remove overt contamination, such as visible faecal releases.

A detailed discussion of the types of control measures that can be applied to prevent disease outbreaks relating to recreational water environments aboard ship is given in chapters 10 to 14. Attention should be given to the contemporary use of a preventative, multiple barrier risk management approach to recreational water safety (WHO 2004b).

5 Ballast Water and Waste Management and Disposal

5.1 Health effects

Unsafe management and disposal of ship wastes can readily lead to adverse health consequences. Humans can become exposed directly, both on ship and at port, due to contact with waste that is not being managed in a safe manner. Exposure can also occur via the environmental transfer of disease-causing organisms or harmful substances due to unsafe disposal. However, waste can be managed and disposed of in ways that prevent harm occurring.

Waste can contain hazardous microbial, chemical or physical agents. For example, sharp objects are in themselves dangerous. Furthermore, those objects may harbour infectious agents. Used syringes are a good example and can transmit disease-causing agents such as hepatitis C virus and human immunodeficiency virus. Furthermore, harmful chemicals can be deposited in waste.

Risks of harm arising due to improperly managed ship waste are increasing with the increasing number of ships in service and the increase in habitation in port areas. Waste streams on ships include black water (sewage), grey water (discard water from deck drains, showers, dishwashers and laundries) garbage, ballast water, effluent from oil/water separators, cooling water, boiler and steam generator blow down, medical wastes (e.g. health care wastes, laboratory wastes and veterinary care wastes), industrial waste water (e.g. from photo processing) and hazardous waste (radioactive, chemical, biological wastes, and unwanted pharmaceuticals).

Food wastes and refuse readily attract disease vectors (see Chapter 8) including rodents, flies and cockroaches which are reservoirs and vectors of etiological agents of many diseases.

Many ships use water as ballast to maintain stability and navigate safely, carrying from 30 to 50% of the total cargo in ballast water. This may represent a volume that would vary from a few hundred litres up to more than 10 thousand tonnes per ship. Therefore, this activity represents an important risk to human health with the possibility of introducing new endemic diseases and spreading disease by transferring pathogens and harmful organisms. In this context, more than 7,000 marine species travel daily and approximately ten billion tonnes of ballast water are transported annually by ship. Concern regarding transfer of ballast water and sediments from ships has increased and there is a theoretical possibility of the transport of hazards such as toxigenic *Vibrio cholerae* O1 and O139 which might then be associated with cholera outbreaks in port areas.

5.2 Standards and guidelines

Medical waste requires special management (WHO Guidelines for HCWM). Specifically, details of health care waste management can be found at http://www.healthcarewaste.org/ and in the Guidelines for Safe Disposal of Unwanted Pharmaceuticals in and After Emergencies WHO/EDM/PAR 99.2 (1999).

Waste management from ships is covered in the IHR and is covered in more detail in MARPOL.

5.2.1 MARPOL 73/78

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) was adopted by the International Conference on Marine Pollution in 1973 and has been subject to numerous amendments as it is updated including the 1978 Protocol and amendments collated into a consolidated version in 2002. Regulations covering the various sources of ship-generated pollution are contained in the six Annexes of the Convention:

- Annex I. Regulations for the Prevention of Pollution by Oil.
- Annex II. Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk.
- Annex III. Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form.
- Annex IV. Prevention of Pollution by Sewage from Ships (entry into force date 27 September 2003).
- Annex V. Prevention of Pollution by Garbage from Ships.
- Annex VI. Prevention of Air Pollution from Ships (adopted September 1997)

5.2.2 Resolution A.868(20)-IMO

The Marine Environment Protection Committee (MEPC) has adopted, since 1993, voluntary guidelines for the prevention of risks of introduction of unwanted organisms through Ballast Water and Sediments from ships. The IMO Assembly, in 1997, adopted through Resolution A.868(20) the "Guidelines for the Control and Management of Ballast Water from Ships" in order to minimize the transfer of harmful aquatic organisms and pathogenic agents.

5.2.3 International Convention for the Control and Management of Ships' Ballast Water and Sediments

The "International Convention for the Control and Management of Ships' Ballast Water and Sediments" was adopted in February 2004. The objective of this Convention is to prevent, minimize and ultimately eliminate the risks to the environment, human health, property and resources arising from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments, as well as to avoid unwanted side-effects from that control and to encourage development in related knowledge and technology. The measures for inspection and control in the management of the sanitary risk of ballast water tank sediments must consider the procedures established in the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments.

5.3 Risk factors

Restrictions on depositing hazardous wastes into water bodies mean that ships need to capture and retain those wastes onboard for periods of time. The presence of stored hazardous wastes leads to the risk of harm arising should stored wastes escape. In addition, the process of packaging and storing hazardous wastes is in itself a hazardous one whereby crew may become harmed due to contact with the waste. The ever more rapid movement of ever more ships around the world increases the risk of transfer of hazardous agents in ballast water.

5.4 Control strategies

Outbreaks and harm associated with waste have been linked to poor storage and disposal practices. Once generated, stored waste becomes a potential source of harm. Therefore, the first disease prevention strategy should be to minimise the amount of hazardous waste generated as far as practicable. It is also necessary to ensure that the systems for collecting and storing waste are adequate given the extent and nature of waste generated aboard ship.

It often necessary to apply treatment systems to help control disease transmission associated with ballast water. However, since treatment systems are fallible, the first control strategy should be to seek the least contaminated practicable source of ballast water in the first place and to discard water as far as practicable from sensitive receiving environments.

In some cases waste management and ballast water treatment systems have failed to perform as required, resulting in unsafe situations. Therefore, reliance should not be placed on treatment and management systems alone. Multiple waste and ballast management barriers should be actively maintained including:

- considering how waste it generated onboard and choosing activities and practices that produce the least harzardous waste in the first place;
- filling with ballast water from safe environments wherever practicable;
- matching waste management and ballast treatment facilities to their required capacities; and
- maintaining sound practices in collecting and storing waste and discharging ballast water.

A detailed discussion of the types of control measures that can be applied to prevent disease outbreaks relating to waste and ballast water aboard ship is given in chapters 10 to 14. Attention should be given to the requirements of the international conventions and guidance cited above (Section 5.2).

6 Legionnaires' Disease

6.1 Health effects

Legionnaires' disease is a potentially fatal form of pneumonia, first recognized in 1976 (WHO Legionella factsheet: http://www.who.int/entity/water_sanitation_health/dwq/en/admicrob4.pdf). The disease is normally contracted by inhaling *Legionella* bacteria deep into the lungs. *Legionella* species can be found in tiny droplets of water (aerosols) or in droplet nuclei (the particles left after the water has evaporated).

Legionnaires' disease is caused by *Legionella* which is the name of the genus of bacteria that includes several species and strains that can cause legionellosis. Ninety per cent of cases of legionellosis are caused by just one species: *L. pneumophila*. The term legionellosis is a general one that describes infections with *Legionella* and that lead to a range of pneumonic (affecting the lungs) and non-pneumonic diseases.

Travelling aboard ship is a clearly established risk factor for legionellosis. There have been many cases of legionellosis acquired on ships (CDC 1994 a, b) with over fifty reports given in the recent WHO review (WHO 2001). For many of these cases, being aboard ship was strongly associated with disease and in many cases there were fatalities. Proper management of wet environments aboard is essential to prevent such outbreaks.

The more than 50 incidents of Legionnaires' disease reviewed included hundreds of cases that were associated with ships between 1977 and 2001. For example, an outbreak of Legionnaires' disease occurred on a single cruise ship in 1994: 50 passengers were affected on one ship during nine different cruises and one passenger died (Jernigan *et al* 1996). The disease was linked to a whirlpool spa on the ship. Staff and maintenance workers can also be affected. For example, in 1997, a boiler repairer contracted Legionnaires' disease on a ship after exposure to warm rusty water leaking into a steam boiler from a tank external to the boiler (Rowbotham 1998).

The problem is not restricted to passenger ships. Surveys carried out on general cargo ships have shown drinking water and air conditioning systems to be contaminated with *Legionella pneumophila* (Temeshnikova *et al* 1996). The same authors noted that serologic surveys of seafarers on cargo ships have shown that a high proportion have antibodies to *Legionella pneumophila*, suggesting that those on board ships are at increased risk of legionellosis compared with communities onshore.

Legionnaires' disease is perhaps the most widely known form of legionellosis. General risk factors for becoming ill include those demographics common on ships: males 50 years of age or older, chronic lung disease, cigarette smoking and excess consumption of alcohol. Although the attack rate is often less than 1% (most people don't become ill following exposure), mortality rates among hospitalized cases can range up to 50% for immuno-supressed patients and for immuno-competent patients it is in the range of 10 to 15%.

Pontiac fever is a non-pneumonic, non-transmissible, non-fatal, influenza-like form of legionellosis. 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.

Transmission pathways for Legionnaires' disease and Pontiac fever are similar are the applicable control measures, such as prevention of contamination, proper disinfection, filtration and storage of source water, avoidance of dead ends in pipes and regular cleaning and disinfection of recreational water environments are required to reduce the risk of legionellosis on ships.

6.2 Standards and guidelines

Legionellosis is not specifically covered for management in the IHR but there is a general overview of responsibilities for responding to and managing suspected or confirmed disease outbreaks on ships (see Chapter 9). A detailed review of the disease can be found in a recent WHO text (WHO 206).

6.3 Risk factors

Legionella bacteria are ubiquitous in the environment where they can complete their life cycle without infecting humans or other animals. They only infect humans opportunistically. Importantly, they can proliferate in water at relatively warm water temperatures, such as those experienced in shower heads and spa pools, and are found in piped water distribution systems and in storage tanks on ships.

Ships are considered to be high-risk environments for the proliferation of *Legionella* spp. for a number of reasons. Water storage and distribution systems on ships are complex and could provide opportunities for bacterial contamination as ship movement increases the risk of surge and back-siphonage. Loaded water may vary in temperature, and in some tropical regions, the risk of bacterial growth is increased because of higher water temperatures. Finally, proliferation is encouraged due to long-term storage and stagnation in tanks or pipes.

Legionella can proliferate in hot and cold piped water systems leading to potential exposure through aerosolisation arising from showers and other plumbing fixtures. It is inhalation of bacteria, or aspiration following ingestion, that is thought to lead to disease, rather than swallowing.

Legionella can proliferate in poorly maintained recreational water environments, such as hot tubs including whirlpools and spa pools and associated equipment. Specific risk factors include frequency of use and length of time spent in or around the recreational water environment.

Poor potable water quality has been linked to outbreaks of Legionnaires' disease on ship (Pastoris *et al* 1999). Increased risk of proliferation of *Legionella* has been associated with drinking-water subjected to periods of stagnation and in systems operating at temperatures ranging from 25 to 50ºC.

6.4 Control strategies

In the first five chapters in this section of the Guide, our emphasis has been on prevention at source, at the earliest possible point in the process by which hazardous agents can reach hazardous levels. However, *Legionella* are ubiquitous in natural environments and it is not practical to avoid the presence of *Legionella* in the first place. Outbreaks arise when water is stored at warm temperatures and aerosols are inhaled. Therefore, the focus of the control strategy must be on controlling temperature and adding biocides to keep pathogen numbers down to safe levels and at the same time reducing the opportunities for inhalation of water.

In practice, a number of outbreaks have been associated with unreliable biocide dosing. Therefore, reliance should not be placed on biocides alone, and multiple barriers should be actively maintained including:

- minimising residence times of stored water;
- maintaining water temperatures either well above or well below levels that are optimal for *Legionella* growth;
- maintaining biocides with reliable, well designed and properly maintained dosing systems; and
- reducing the opportunity for aerosol generation and inhalation.

A detailed discussion of the types of control measures that can be applied to prevent disease outbreaks relating to *Legionella* aboard ship is given in chapters 10 to 14. Attention should be given to the contemporary use of a preventative, multiple barrier risk management plan, (WHO 2006) analogous to the drinking-water safety plan approach (WHO 2004a; Davison et al 2005).

7 Persistent Infectious Agents

7.1 Health effects

There have been a number of outbreaks of infectious gastrointestinal disease on ships caused by persistent infectious agents. For example, in 2002 the US Centres for Disease Control detected 21 such outbreaks (in this case defined as *probable Norovirus infections causing illness in > 3% of the ship population*) aboard ships arriving at US ports (CDC 2002). In general, diseases arising from persistent infectious agents result from infection of the gastrointestinal system (digestive tract, intestines, stomach) and cause symptoms such as nausea vomiting and diarrhoea. Although often self-limiting or even asymptomatic, deaths can arise, particularly in sensitive populations. In the confines of a ship environment these diseases can spread rapidly to affect significant proportions of the total ship population.

The subject of this chapter are the infectious agents that have the ability to persist in air, water, vomitus, sputum and on surfaces for long enough that an environmental surface, such as a door handle, or transmission through air, can lead to transfer indirectly from one person to another readily and an outbreak can occur. An infected person might, for example, be shedding an infectious agent *via* their faeces or vomitus. After bottom-wiping, nappy-changing or cleaning they, or their carer, might carry some of this material on their hands, unless thoroughly washed, leaving it on surfaces or in food or water that they touch around ship. When another person touches those surfaces or consumes the food or water they might pick up the infectious agent, which can then be ingested when putting fingers in the mouth or through ingestion of contaminated food or water. Waterborne and foodborne transmission of such agents may also occur and this is considered in Chapters 2 and 3 respectively. This Chapter considers the risks associated with transfer of infectious agents *via* environmental surfaces, such as door handles, (faeces → hand → surface → hand → mouth) and also considers how these same agents can be transmitted via the air.

Many infectious agents can spread via environmental surfaces, including some protozoa, bacteria and viruses. However, to cause a detectable and significant outbreak aboard ship the agents also need to be highly infectious and be able to rapidly complete their incubation and begin replicating in their new infected host. For this reason, the environmentally persistent agents that cause gastrointestinal disease outbreaks aboard ships are generally viruses. Our knowledge of these viruses and their taxonomy is rapidly evolving. However, in general, the risk factors and control measures to be applied aboard ship are the same regardless of the taxonomic classification of the infectious agent.

Persistent infectious agents are typically viruses belonging to the Calicivirus, Astrovirus and Reovirus families. These viruses are commonly associated with diarrhoea, with the Calicivirus family including the genus most commonly associated with ship-borne outbreaks: Norovirus (NV) (which has also been known as Norwalk–like virus (NLV) and small round structured virus (SRSV)).

Because of the similarity between symptoms and control measures, NV will be used in this chapter to illustrate the risk factors and control measures to be applied aboard ship. NV is considered the leading cause of adult gastroenteritis outbreaks worldwide and is thought to be second only to Rotavirus in terms of all causes of gastroenteritis. Recent improvements in diagnostics and surveillance are likely to reveal more outbreaks aboard ships. The probable role of international travellers as vectors was revealed by the similarity of strains between outbreaks across the world (White *et al* 2003).

NV can be transmitted by the aerosols liberated by projectile vomiting and, therefore, by airborne transmission (Marks *et al* 2001) as well as *via* ingestion, (both directly or indirectly via a surface) of infected vomit and faeces. Environmental surfaces can become contaminated readily and remain contaminated for some time (Cheesbrough *et al* 2000).

An outbreak can spread rapidly throughout a ship because NV has an incubation period of just 12 to 48 hr and an attack rates (proportion of those exposed that fall ill) can be high (often above 50%) in all age groups (CDC 2002). Symptoms often start with sudden onset of projectile vomiting and/or diarrhoea. There may be fever, myalgia, abdominal cramps and malaise. Recovery occurs in 12 to 60 hr in most cases and severe illness or mortality is rare, particularly if oral rehydration treatment is applied when needed.

Because the infectious agents are persistent, outbreaks may continue and attack passengers and crew on successive voyages. Cohorts of new susceptibles are introduced on a regular basis during crew and passenger changeovers so it is important to sanitise ships after an outbreak to reduce this risk.

Shedding rates for Noroviruses have been found to peak at over 10^6 virions per g faeces, dropping to around 1,000 virions per g faeces three weeks from the cessation of symptoms in around 50% of cases and remaining detectable for up to 7 weeks following the peak of infection (Ball *et al* submitted). Therefore, even if ships are sanitised, bridging between groups may occur *via* a reservoir of infection in crew members. Another important implication of this prolonged shedding period, noting that it is often asymptomatic, is that some passengers and crew are likely to bring these persistent infectious agents aboard with them regardless of what the crew does. It should be assumed that there are unrecognised infected individuals aboard ship even in the absence of a detectable outbreak, and infection control precautions should be implemented continuously, not just after the outbreak has taken hold.

Cruise-ship outbreaks demonstrate how easily Noroviruses can be transmitted from person to person in a closed environment, resulting in large outbreaks. The continuation of these outbreaks on consecutive cruises with new passengers and the resurgence of outbreaks caused by the same viral strains during previous cruises on the same ship, or even on different ships of the same company, suggests that environmental contamination and infected crew members can serve as reservoirs of infection for passengers.

More recently, severe acute respiratory syndrome (SARS, (WHO 2004c)) has been noted as a disease that might be spread by travellers or on ship. This disease, caused by a Coronavirus, has symptoms that are typically different from the gastrointestinal viruses described above and is associated with respiratory tract infection and flu-like symptoms. However, although initially presenting rather like influenza, complications can include sever pneumonia and respiratory system failure which can be fatal. The risks from the person-to-person spread of SARS appear to be reduced by the same types of control measures applied for NV and similar agents.

7.2 Standards and guidelines

Control of persistent infectious agents is not specifically covered in IHR but there is a general overview of responsibilities for responding to and managing suspected or confirmed disease outbreaks on ships (see Chapter 9).

7.3 Risk factors

Risk factors for infection from viruses such as NV are generally those that involve being in close proximity to an infected person including (based on de Wat *et al* 2003):

- having another infected person in the same family or group;
- coming into contact with an infected person;
- poor food and water handling hygiene;
- the significance of contact with other infected persons increases where the infected person is a young child; and
- contact with both faeces and vomit appear to be equally important as one another.

Ships present a particularly high risk for extensive outbreaks for several reasons. Many outbreaks on land have been associated with situations in which many people are in close proximity to other infected persons for a period of time, such as parties, restaurants, schools and dormitories. These high-risk situations can all be present on one ship where the problem is compounded by them being in close proximity and by people sharing the same facilities for days to weeks. Cabins often include people living in close proximity, often with children, that might otherwise be more separated.

7.1 Control strategies

The first five chapters in this section of the Guide emphasise prevention at source above all other control strategies. However, NV are so prevalent in the population, often without symptoms being evident, and it is not realistic to try to exclude NV infected individuals coming aboard. Outbreaks arise when there is inadequate control of possible infection pathways aboard ship. Therefore, the focus of the control strategy for NV should be on taking all reasonable precautions to prevent transmission of persistent infectious agents at all times. It is worth noting, however, that symptomatic individuals are particularly infectious, and there is value in taking extra precautions relating to such individuals, seeking to minimise the possibility of patients contaminating others aboard ship.

Reliance should not be placed on any single control strategy, and multiple barriers should be actively maintained including:

- advising, or even requiring, symptomatic individuals to minimise contact with others;
- maintaining stringent food and water handling hygiene;
- providing separate areas for children and adults;
- providing good ventilation;
- providing ready access to washing facilities;
- sanitising fomites; and

- rapidly sanitising and cleaning up any faeces or vomit spilt on ship.

A detailed discussion of the types of control measures that can be applied to prevent disease outbreaks relating to persistent infectious agents aboard ship is given in chapters 10 to 14.

8 Disease Vectors

8.1 Health effects

The control of disease vectors such as insects and rodents is necessary for the maintenance of health and healthful conditions aboard ships. Mosquitoes, rates, mice, cockroaches, flies, lice, rats fleas and bedbugs, are all capable of transmitting disease.

Rats and mice are well established at port areas. Rats from ships can be vectors for many diseases. Plague, murine typhus, salmonellosis, trichinosis, leptospirosis and rat bite fever are known to be spread by rats.

Malaria is transmitted to humans by mosquito vectors. If not properly controlled, such vectors could breed on ship and could certainly be carried by ship. Infection with malaria during voyage represents a serious risk to health and life. On board ship, the chances for early diagnosis and proper treatment are limited. Outbreaks have been reported in Japan, Poland, Ukraine, Lithuania, Spain and Denmark. For example, there were 221 reported cases of malaria among crew of Spanish ships from 1988 - 1994.

Ships can spread disease to ports via infected vectors. For example, in 1993 acute malaria was diagnosed in 2 residents of Marseilles, France, who lived close to the harbour. Neither of the patients had received blood transfusions or had travelled outside France. Entomological investigations confirmed the absence of Anopheles mosquito breeding sites in the port area. Disease transmission was thought to have occurred following the introduction of one or more mosquitoes by a ship arriving from tropical Africa. Weather conditions in the summer of 1993 were favourable for the survival of Anopheles and the completion of the malaria parasite life cycle. Doctors were advised to consider malaria in the differential diagnosis of fever of unknown origin in any patient working or living in or near the harbour area (Delmont et al, 1994).

8.2 *Standards and guidelines*

Article 20 of IHR directs health authorities to ensure that ports have the “capacity” to inspect ships and then to issue either “Ship Sanitation Control Certificates” to direct disinfection or decontamination of the ship, including the control of vectors, or “Ship Sanitation Control Exemption Certificates” if contamination is not found.

Annex 1 of IHR describes what constitutes this “capacity” and notes that this includes the capacity to decontaminate ships.

Annex 4 of IHR describes the process of issuance of such “certificates” and states that the presence of vectors, not necessarily evidence of disease *per se*, is sufficient basis for the issuance of the Control Certificate to decontaminate the ship of those vectors.

Annex 5 of IHR describes the controls for vector-borne disease and provides health authorities with the right to control vectors found.

8.3 Risk factors

Ports receive and manage goods and people from all over the world. Therefore, ports are exposed to the risk of introduction of vectors from any other part of their host country or any other port in the world. In addition, the activities undertaken at ports, such as handling foodstuffs, attracts many species of vermin. Once aboard ship, being relatively isolated from medical facilities makes diagnosis and treatment of disease more difficult and potentially increases the risk of serious adverse harm. The relatively crowded nature of ships facilitates the spread of disease and ensures a concentration of foodstuffs and hosts for vectors.

8.4 Control strategies

Outbreaks associated with vectors aboard ship are usually linked to both inadequate control and sanitation aboard ship and to insufficient attention to preventing contamination in the first place. The failure of initial prevention leads to contamination which is then exacerbated by failed ongoing control. Therefore, multiple barriers should be actively maintained including:

- screening out vectors using all reasonable means;
- sanitising ships to control vectors onboard;
- avoiding providing habitat suitable for vector survival and breeding; and
- reducing the opportunity for exposure of passengers and crew to vector-related infectious agents.

A detailed discussion of the types of control measures that can be applied to prevent disease outbreaks relating to vectors aboard ship is given in chapters 10 to 14.

9 Roles and Responsibilities

9.1 Accountability and responsibilities

Infectious diseases aboard ship may exact a considerable toll on the operational capacity of marine vessels, and in extreme circumstances become impediments to international commerce and travel. The prevention of such incidents and the proper response should they occur is a top priority for all those responsible for ship design, construction and operation.

The major roles of accountability aboard ship that relate to maintaining a safe environment for passengers are assigned to the Owner, Operator, Engineer, Master and Surgeon. Each must play their part in identifying health hazards, controlling risks and managing the ship to ensure safety.

In this chapter roles and responsibilities and their inter-relationship are discussed in outline with the following three chapters providing further details on the specific roles and responsibilities of the major parties.

9.1.1 Designer/Constructor

The role of the ship Designer/Constructor is discussed in detail in Chapter 10.

Good, sanitary design greatly reduces the chances of poor health outcomes arising aboard ship or at port and due to a ship. Therefore, those that design and construct ships need to ensure that their ships can be readily operated in a sanitary manner.

The construction and layout of the ship should be suitable for its intended purposes once operational. This requires attention to important details of design and construction that affect sanitation on ship. The better and more failsafe a ship's sanitary design, the easier it is for the Owner/Operator to do the right things and the inherent risk is minimised. On the other hand, a ship's design that has many flaws, and places excessive reliance on operational practices, is likely to lead to outbreaks eventually.

9.1.2 Owner/Operator

The role of the ship Owner/Operator is discussed in detail in Chapter 11.

Upon receiving a vessel, the Owner of the ship should ensure compliance with sanitary design standards that support sanitary ship operation. Examples include the need to ensure that clean food and water can be physically separated from waste and the need to ensure that design capacities for facilities such recreational water environments are adequate. Responsibility for ensuring that a ship received is designed and built in a manner that does not expose passengers and crew to unacceptable health risks rests with the ship Owner. The Owner bears the ongoing responsibility to ensure the ship design is fit for the purpose to which the ship will be put.

Responsibility for ensuring the ship can be operated in a manner that provides a safe environment for passengers and crew rests with the ship Operator. The Operator must ensure that there are sufficient resources and provisions, properly maintained and adequate equipment and facilities and adequately trained and sufficient crew to properly manage health risks aboard ship.

9.1.3 Master/Crew

The role of Master/Crew is discussed in detail in Chapter 12.

Responsibility for all aspects of crew safety aboard ship is vested with the ship's Master (Captain), as delegated by the Operator and by maritime convention. Responsibilities are often delegated such that they effectively become shared, although not abrogated, via the chain of command. The Master must ensure that all reasonable measures are taken to protect crew and passenger health. The following chapters make reference to operational control measures and note the importance of ongoing attention to monitoring control measures. The conscientious and diligent operational monitoring of these operational control measures is the responsibility of the Master and Crew.

The ship Engineer is likely to be chiefly responsible, as delegated by the Master, for the proper operation of the engineered systems that protect passenger safety. This includes many aspects the ships operation including the cooling and heating systems designed to maintain food and water at safe temperatures, water treatment systems for drinking, waste management and recreation and the integrity of piping and storage systems.

The ship Surgeon has special responsibility in relation to ship sanitation and public health protection. They are the most likely to detect an outbreak early and, through notification, alert the Master to the need to take action to investigate and contain the outbreak. The ship Surgeon will need to ensure that a log is kept of disease notifications and should undertake a surveillance role, defined here as the timely and appropriate collection of health information and the identification of possible shipboard health problems.

9.1.4 Port authorities

The role of port authorities is discussed in detail in Chapter 13.

The primary responsibility of port authorities is to provide the required infrastructure, equipment, facilities, expertise and materials so that ships can obtain undertake operations in a sanitary manner. This means being able to provide safe food and water and to safely remove ballast and waste.

Prevention of contamination at source to maximum extent practicable is a key tenet of preventative control strategies. Since ships load at ports, the port authorities play a vital and anchoring role in protecting public health by seeking to provide the best practicable raw materials for ships.

9.1.5 Port health authorities

The role of port health authorities is discussed in detail in Chapter 14.

The primary responsibility of port health authorities is to respond to requests for help from the ship Master/Crew as well as to undertake surveillance, outbreak detection and control.

Rapid identification and response to illness among passengers or crew is essential to maintaining a safe working environment by enacting public health interventions and controlling the spread of disease. Coordinated surveillance systems can facilitate public health efforts to prevent and control disease, injury, and disability related to the interaction between passengers, crew, and their environment.

With the exception of some large naval vessels, few ships have the resources or expertise to conduct investigations into shipboard disease outbreaks. Therefore, the ship Surgeon should call for help should the need arise. Most nations have public or occupational health professionals who are trained to perform such investigations and recommend the appropriate response measures.

9.2 Summary

In summary, there are distinct roles for the different organisations and individuals in maintaining good sanitation on ships. However, the objective of good ship sanitation is a common one that requires all to play their part. From design, through construction, procurement, operation and docking, all professionals involved in shipping have an important role to play as part of the multiple barrier, preventative risk management approach to protecting passengers, crew and port populations from harm.

10 Designer/Constructor

10.1 Introduction

From a public health perspective, the Designer/Constructor can predispose the ship to probable success or probable failure depending on the attributes of the sanitary control measures built into the ship's design and the quality of their construction. This chapter describes the sanitary design and construction requirements for ships and is structured into sections in accordance with the overall structure of this Guide.

10.2 Water safety

10.2.1 Providing sound plumbing in general

Ships should have plumbing suitable for the protection of water safety. Before being supplied, new ships should be inspected for compliance with the design specifications that need to be met to ensure safe water as part of commissioning/completion, as part of normal ship construction inspection. A clear and accurate layout of the engineered system on the ship is likely to be needed to support this.

Using suitable materials

Materials in contact with water need to be safe for that use. To help ensure this, in new construction and in repairs and replacements on old vessels, new pipe, tubing or fittings can be used in the potable water system, and in the wash water system when wash water may be used to supplement potable water after treatment. All materials used will likely need to be acceptable to the national health administration of the country of registration. Lead- and cadmium-lined pipes, fittings and joints should not be used anywhere in the potable water supply system as these can contaminate water. Materials and devices would need to be suitable for hot/cold water use, as applicable. In selecting materials for contact with water, certification authorities should take account of corrosion and microbial growth potential in their testing regimes to help ensure adequate asset life and water quality.

Preventing backflow

To ensure proper protection of higher from lower qualities of water and waste, plumbing systems need to have appropriate devices selected for each specific application. There are a number of ways of achieving this, as follows.

Air gaps

An air gap is the unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle or receiving fixture.

An accepted safe practice is to ensure that the length of an air gap is at least twice the inside diameter of the delivery pipe or drain that it protects. When a receiving funnel is provided, the gap would be measured from the top of the funnel to the end of the pipe or drain.

Back flow preventers (vacuum breakers)

When an air gap cannot be provided in the water-supply line to a fixture, an accepted safe practice is to ensure that the a suitable back flow preventer is installed in the supply line on the discharge side of the last control valve. A proven aspect of this practice is to install the back flow preventer a suitable distance, such as at least 10 cm (4 in), above the flood level rim of the fixture. The back flow preventer would need to be so designed that a complete cycle of any moving parts is made each time the control valve and the supply line are opened and closed.

A back flow valve is a mechanical device installed in a waste line to prevent the reversal of flow under conditions of back pressure. In the check-valve type, the flap would need to swing into a recess when the line is flowing full, to preclude obstructing the flow.

The following are general recommendations for common types of backflow preventers and their recommended uses:

- Atmospheric vacuum breaker - An approved backflow prevention plumbing device utilized on potable water lines where shut-off valves do not exist downstream from the device. The device is not approved for use when it is installed in a manner that will cause it to be under continuous water pressure. An atmospheric vacuum breaker is typically installed at least 152 mm (6 in) above the flood level rim of the fixture or container to which it is supplying water.

- Continuous pressure backflow preventer - An approved backflow prevention plumbing device with two check valves and an intermediate atmospheric vent that is designed and approved for use under continuous water pressure (e.g. when shut-off valves are located downstream from the device).

- Hose bib connection vacuum breaker - An approved backflow prevention plumbing device that attaches directly to a hose bib by way of a threaded head. This device uses a single check valve and vacuum breaker vent. It is not approved for use under continuous pressure (e.g. when a shut-off valve is located downstream from the device).

- Reduced Pressure Principle Backflow Prevention Assembly (RP Assembly) - An assembly containing two independently acting approved check valves together with a hydraulically operating, mechanically independent pressure differential relief valve located between the check valves and at the same time below the first check valve. The unit would typically include properly located resilient seated test cocks and tightly closing resilient seated shutoff valves at each end of the assembly.

Providing sanitary fixtures

Fixtures and fittings can themselves harbour contamination and the design needs to consider how to select suitable attributes to control these risks. To maintain their integrity, an accepted safe practice is to ensure that the all fixtures are resistant to the corrosive effects of salt water and saline atmosphere. In addition, fixtures would typically be easy to clean, and designed so as to function easily and efficiently. To aid cleaning, internal corners are best if rounded, wherever practicable.

Aboard ship, any bidets installed would typically be of the jet type and any potable or wash water line serving them would be equipped with a back flow preventer.

Wash-basins would ideally have hot and cold water lines ending in a simple mixing outlet to help control growth of bacteria that would otherwise proliferate in warm water lines. It is useful to encourage sanitary passenger and crew behaviour by placing a sign above the basin which would read something like “WASH BOWL BEFORE AND AFTER USE”.

Ensuring a sanitary drainage system

Drains would need to be of adequate size to prevent clogging and subsequent back flow of sewage or contaminated waste into the fixtures and spaces they serve. Provision may need to be made to prevent pipes from freezing which could lead to pipe damage and potential contamination.

To prevent cross-contamination, ideally, no drainage line of any kind, nor any pipe carrying wash water, salt water, or other non-potable liquid, would pass through any potable water tank. Similarly, soil-waste drains are best not to pass over potable water tank or wash water tank manholes. For the same reasons, it is best if toilets and bathroom spaces do not extend over any part of a deck that forms the top of a potable water or wash water tank.

Food can also be contaminated by wastewater. Therefore, it is advisable to ensure that all non-potable water piping (service and drainage lines) is so installed that it does not pass directly over or horizontally through spaces where food is stored or prepared, spaces where utensils are washed, or spaces from which food is regularly served. In instances where such installation may impose an undue hardship in connection with the location of drainage piping, special consideration should be given by the national health administration to alternative construction involving the use of special piping materials and installation practices in order to prevent the possibility of leakage. Examples of stronger and more corrosion-resistant drainage line materials that may be accepted in such construction, are extra-heavy, galvanized steel with welded joints, galvanized standard wrought iron with welded joints, cupro-nickel alloy tubing (containing at least 10 % nickel) with silver-brazed joins, or other materials approved by the national health administration. In addition, it is advisable for the system to be hydro-statistically tested for leakage, and ideally no clean-outs would be provided over such spaces. Joints may be butt-welded provided but if so, it is preferable that no welding bead remains within the pipe. Butt-welding may be avoided by the use of a sleeve coupling which is welded at the ends of the sleeve. Chemical welding is also acceptable.

If the high rotary action of a food refuse grinder or disposal unit located in a scullery or other food service area causes an aerosol spray, an eductor using wash water or salt water can be provided in the horizontal discharge line from the grinder or disposal unit to remove contamination. Such an installation is not necessary for grinders installed in food refuse disposal areas or food refuse grinder rooms separate from areas where food is prepared or served, or in dish washing areas.

To help prevent cross-contamination, ideally, when fresh water from overboard is to be treated aboard a ship for use as potable water, the sanitary overboard discharges would not be on the same side as the water intake. When it is not practicable to locate the sanitary overboard discharges on the opposite side of the ship from the water intake, they would ideally be located as far aft of, and as far above the water intake as practicable. It is not advisable to allow drain lines carrying sewage, food particles or other putrescible matter to be discharged to the bilge.

Potato starch is an excellent substrate for microbial growth. Therefore, if open drains from a potato peeler are discharged into a sink in any of the food spaces, it is recommended that the sink is not routinely used for washing dishes and utensils.

To help reduce food waste build-up, deck drains are often provided in food preparation and food storage spaces. The need for such drains in other spaces is subject to the requirements of the particular ship. Curbings installed for any purpose are best designed so as not to prevent proper drainage of the deck surface.

Vents and traps

Drainage systems that receive sewage, ablutionary water or other putrescible waste would ideally have such vents and water sealed traps as may be necessary to prevent gases or obnoxious odours from entering any space served. The water sealed traps would ideally be so designed as to minimize the deposition of settleable solids and would be of the same size as the drains to which they are connected. When there is an air gap in the drain, the trap would ideally be installed below the air gap and the traps easily opened for cleaning. It is advisable to vent sewage-holding tanks to the outside of the vessel so that they are independent of all other tanks and are away from any air intakes.

Clean-outs

To reduce cross-contamination risks, clean-out and "rodding" plugs would ideally not be installed in those parts of drainage systems that are near potable water tank manholes or that pass overhead in spaces where food is prepared, handled, stored or eaten; in spaces where kitchen utensils are stored; in hospital, surgical and medical care spaces; or in refrigerated spaces.

Sanitary connection for single overboard discharge

The drainage systems can be connected to other systems carrying human sewage or hospital wastes, for the purpose of having one common overboard discharge. To help reduce cross-contamination risks, it is worth considering certain controls, such as:

- Placing the connection adjacent to the shell opening and at a suitable distance, such as about 90 cm (3 ft) from the shell.
- Having each food waste drain connected to the overboard discharge line equipped with a back flow valve located adjacent to the connection.
- Having the overboard discharge carrying the combined drainage kept free of checks and other obstructions (except the usual flap valve at the shell), and its diameter being sufficient for its purpose, such as at least equal to that of the largest serviced line, and in any case not less than 10 cm (4 in). Valves required for other purposes can be inboard of the junction on the soil line, and inboard of the back-water valve on the food waste drain.
- Overflow tell-tale deck drains can be provided in the food waste systems.
- When a refrigerated space is located on the inner-bottom plating and its drains go to a drain well which, in turn, is emptied with a separate pump, steam operated ejector, or bilge pump, a tell-tale deck drain can be connected to the drain well. The diameter of the tell-tale drain needs to be sufficient, such as being at least equal to that of the suction line

to the pump.

10.2.2 Protecting the safety of potable water

Reference can be made to two important standards in relation to sanitary design and construction of ship water supplies (http://www.iso.org/iso/en/ISOOnline.frontpage):

- ISO 15748-1: 2002 – Ships and marine technology – Potable water supply on ships and marine structures – Part 1: Planning and design.
- ISO 15748-2: 2002 – Ships and marine technology – Potable water supply on ships and marine structures – Part 2: Method of calculation.

To protect the health of passengers and crew, water to be used for potable purposes aboard ship would ideally be provided with sanitary safeguards from the shore source, through the shore water distribution system, including connections to the ship system, and through the ship system to each outlet in order to prevent contamination or pollution of the water during ship operation. For simplicity, whenever practicable, it is useful to have only one water system installed to supply potable water for drinking, culinary, dish-washing, ablutionary, hospital and laundering purposes. Where dual systems are installed or required, it is sometimes acceptable for potable water not to be piped to slop sinks, laundry facilities, water closets and bibcock connections used for deck-flushing and cleaning purposes.

When considering coatings, if the material of which systems are constructed should require coating, it is important that such coating not render water unfit for human consumption.

Prevention of back flow

To prevent cross contamination it is advisable to ensure that the potable water system is not connected to any non-potable water system. To achieve this, overflows, vents and drains from tanks, and drains from the distribution system (including any treatment plan) would not be connected directly to sewage drains. When drain lines are extended towards the bottom of the ship, they would terminate a suitable distance, such as at least 45 cm (18 in), above the inner-bottom plating, or above the highest point of the bilge in the absence of such plating, unless back flow is impossible. Air gaps and receiving funnels would be installed in these lines when they discharge to a closed tank of a non-potable water system, to deck drain, or to a sanitary drain.

A standard backflow preventer or other device to prevent the flow of water from vessel to shore can be installed on every ship. Backflow preventers would need to permit effective maintenance, inspection and testing. Drainage to prevent freezing may need to be provided.

Individual air gaps can be placed in the drain lines from certain types of fixtures, such as water-bath sterilizers, hospital water stills, autoclaves, steam kettles, drinking glass rinsers, vegetable peelers and coffee urns, as well as from all hospital, food preparation and food servicing equipment that may be subject to sub-atmospheric pressure.

Air gaps can be placed in the individual drain lines from refrigerated cargo spaces, the ship’s stores refrigerators, dry-store space, dish washers, and equipment used in the preparation or processing of food, when such drainage is to a system that receives human sewage or hospital wastes. Individual air gaps might not be required in these drains if conditions such as the following are satisfied:

- The drains are independent of each other and of all other drainage systems.
- The drain lines discharge to open drain wells; when the drain line runs from equipment that may be subject to sub-atmospheric pressure, the end is not be merged in the drain well.
- The drains from such equipment and spaces are connected to a common drainage system separate from any system carrying human wastes, and there are tell-tale deck drains in each food storage and food preparation space, with the exception of refrigerated spaces, for which a deck drain outside the space will suffice. In the latter case, the tell-tale deck drain would be in adjacent, frequented space or passageway, and at a level of, for example, 15 cm (6 in) or more below that of the drain in the floor of the refrigerated space.

Non-return valves are preferred to tell-tale deck drains in drainage line from refrigerated cargo spaces. This system can be connected to a human sewage or hospital waste drainage system for the purpose of having one common overboard discharge.

The food waste drainage systems may discharge by gravity directly overboard or through air gaps to other drainage systems. Pumps or steam operated ejectors are satisfactory in continuous drainage systems that discharge above or below the waterline, regardless of the elevation of the spaces drained, provided that tell-tale, overflow deck drains are installed. Ejectors that are operated by overboard water are best not installed in continuous systems. When wastes from these food storage and food preparation spaces are discharged through an air gap to a sump and ejected by means of an overboard water operated ejector, this installation is more acceptable.

Ensuring sanitary watering facilities at the port

Port watering facilities include all piping, hydrants, hoses and any other equipment necessary for the delivery of water from shore sources at the pier or wharf area to the filling line for the ship's potable-water system.

Plans for construction or replacement of facilities for loading potable water aboard vessels can be submitted to the health administration, health authority, or other designated authority for review. Plans can show location and size of distribution lines at pier or wharf area; location and type of check valves or other back flow preventers; location and types of hydrants, including details for protection of outlets; storage facilities for the protection of filling hose and attachments and other pertinent information.

Pier or wharf water-distribution system

The lines' capacity would ideally be such as to maintain positive pressure at all times. The lines can be located above normal high-water level in the harbour. Valves can be provided for the cut-off of each hydrant.

There would ideally be no connections between the potable-water system and other piping systems. To prevent contamination of the potable-water supply, all such connections can be removed, unless approved by the health authority, and approved back flow precautions installed.

Back flow of contaminated water into the potable-water system can be prevented by proper installation of piping and plumbing. For example, potable water for priming a pump used to deliver non-potable water for fire fighting purposes can be delivered to the pump through an air gap.

Protection against back flow from vessels to shore

When a ship is without power to operate its pumps, it may connect its fire fighting system to the shore potable-water system. If the connection remains after the ship's power system is restored, it may happen that, when the latter is tested, non-potable water from the ships fire-system is accidentally pumped back into the shore potable-water system. The installation of a back flow preventer between ship system and shore system will prevent such accidents. For example:

- A standard back flow preventer or other device to prevent the flow of water from vessel to shore can be installed on every ship which is constructed or reconstructed. However, there are many ships in service not now equipped with thee devices. For this reason, it may be necessary to install back flow preventers on shore at each hydrant.

- Single-check valves do not provide the same protection as double-check valves, differential-pressure back flow preventers or complete separation, but are less expensive and easier to install and maintain. They require frequent inspection to ensure proper operation. Pumping against a check valve may well result in a burst hose.

Approved back flow preventers need to be properly installed to permit effective operation and inspection. Drainage to prevent freezing may need to be provided.

Hydrants

Hydrants, taps and faucets, can be designed to prevent contamination of the potable water. They can be located high enough to avoid submergence by normal high water and tidal action which may lead to back flow. Non potable water hydrants are not normally located on the same pier as hydrants for potable water unless absolutely necessary. Potable water hydrants can be identified with signs such as "POTABLE WATER" and non-potable water hydrants with signs marked "NON POTABLE WATER". The following conditions are recommended:

- Hydrants, unless adequately and continuously covered, would be located so that they will not receive discharge from the waste lines or scuppers of a ship.

- Hydrants would not be located in toilets, wash-rooms or similar places.

- Hydrants, hydrant supply lines or outlets would be located high enough to avoid submergence by normal high water and tidal action.

- Hydrants, unless adequately protected by housing or cover, would have their outlets ending a suitable separation distance, such as at least 45 cm (18 in), above the platform or pier surface. The outlets would terminate in a horizontal or downward direction and would be provided with caps and keeper chains.

- Where hydrant outlets are less than a suitable separation distance, such as 45 cm (18 in) above the pier, the following protection against contamination can be provided:

- Adequately constructed housings or covers can be used. These can be durable enclosures and the sides and top can be watertight. They may open be open at the bottom. When hydrant boxes are used, the box drains can discharge to the water surface beneath the pier, or to the ground. Drains can be of sufficient size to carry away all excess water. Drain-pipes would not be connected to sanitary or storm sewers, except through an air gap.

- Each hydrant box can have overflow openings in the sides, not less than a suitable distance, such as 5 cm (2 in), in diameter, with a suitable distance to the spill-line, such as at least 2.5 cm (1 in) below the lowest edge of the opening. When adequate drainage is provided and maintained, overflow openings are not always required. Openings could be provided with caps and keeper chains, unless protected by self-closing covers.

- Drainage lines from supply lines or hydrants can terminate above normal high-water level or the surge of water from incoming ships.

Where compressed air is used to blow water out of lines and hydrants for cleaning or draining, a filter, a liquid trap, or similar device can be installed in the supply line from the compressed-air system to protect the water supply.

Safe watering facilities on board ships

To provide for safe watering, every potable water tank would ideally have a dedicated, clean filling line to which a hose can be attached. This line should not be cross-connected with any line of a non-potable water system. Each filling line can be marked, such as with the words "POTABLE WATER FILLING". The filling line needs to be positioned a suitable distance, such as at least 45 cm (18 in), above the deck and is typically painted or marked in blue.

Filling hose

To help protect the quality of water passing through them, any filling hoses would need to be sufficiently durable, with a smooth, impervious lining, and equipped with fittings, including adapters, so designed as to permit connection to the shore potable-water hydrants and filling connections and to prevent their use for loading other liquids.

For storage, special lockers can be designated and marked something like "POTABLE WATER HOSE ONLY" in letters large enough to easily see, such as more than 2.5 cm (1 in) high; lockers can be closed, self-draining, and fixed high enough above the deck, such as 45 cm (18 in). The lockers would need to be constructed from smooth, non-toxic, corrosion resistant and easily cleanable material. Hose and fittings need to be maintained in good repair.

Filling line

For every potable-water tank, regularly or occasionally filled by hose, an independent filling line to which a hose can be attached is needed. To prevent contamination of water, this line should not be cross-connected with any line of non-potable-water system and should not pass through any non-potable liquid. Lines to divert potable water to other systems by valves or interchangeable pipe fittings are not generally considered acceptable, except where an air gap follows a valve. If one filling line is used to load potable water only to all tanks, a direct connection between the potable-water tank and other tanks through an air gap is a satisfactory practice.

To prevent contamination of water, the filling line can begin, either horizontally or in a gooseneck pointing downwards, at a point a suitable distance, such as at least 45 cm (18 in), above the top of the tank or of the deck which the line penetrates. The filling line can also be painted or striped auxiliary blue and labelled. Screw threads, or other devices permitting hose attachment on the end of the potable-water filling line can preferably be different from the threads or devices on other filling lines and on fire hydrants. The filling line can have a screw-cap or plug fastened by a chain to an adjacent bulkhead or surface in such a manner that the cap or plug will not touch the deck when hanging free. Each filling line can be clearly marked with words such as “POTABLE WATER FILLING” in suitably large letters such as at least 1.25 cm (0.5 in) high, stamped on a non-corrosive label plate, or equivalent, and located at or near the point of hose connection.

Safe use of water-boats and water-barges

To help ensure only safe water is supplied to ships, water-boats and water-barges are vessels specially constructed and equipped to receive and provide water for both potable-water and non-potable-water systems aboard ships under conditions where direct shore delivery is not practicable. These craft need to be completely equipped with independent potable water tanks, water hose and hose fittings, pumps and independent pipe systems to provide potable water only to potable-water systems on ships. The reception, handling, storage and delivery to ship water systems would need to be carried out under completely sanitary conditions to protect water safety. Facilities for disinfection may need to be available when and where necessary. Plans for the construction of these craft may need to show filling lines, storage tanks, pumping equipment and protective measures for approval by the health authority. Provision needs to be made for the protection of these craft against contamination of lines, tanks and equipment, when not in use.

Safe potable water storage

Potable water needs to be stored in tanks that are so constructed located and protected as to be safe against any contamination from outside the tank. Tanks need to be designed so that cross connections between tanks holding non-potable water or pipes containing non-potable water are prevented.

Potable water tanks would need to be constructed of metal or other suitable material safe for contact with water and robust enough to exclude contamination. Tanks should ideally be independent, having no common partition with a tank holding non-potable water or the hull of the ship. Ideally, no toilet or urinal should be installed over that part of a deck that forms the top of a potable water tank. Similarly, no drain-line or pipe carrying non-potable liquids should pass through the tank unless a tunnel of acceptable construction is provided. Ideally, lines carrying sewage or other highly contaminated liquids should not pass directly over the manhole in the tank.

The potable water tank will need an inspection cover giving access for cleaning, repair and maintenance. Sample cocks can be installed on each tank to allow tests to be taken to verify water quality and would ideally point downwards to avoid contamination. These sample cocks would need to be identified and numbered.

Ideally, potable water tanks would be located in rooms that have no sources of heat emission and dirt. In exceptional cases if, for technical reasons, it is found impossible to satisfy this requirement, it is possible to place them in rooms with heat emission, but then effective action for water protection against heating is required to prevent proliferation of bacteria.

If the material of which a tank is constructed should require coating, such coating should not render the water stored therein toxic or otherwise unfit for human consumption. Proper maintenance of anticorrosive coatings in water tanks is important. It is best if each tank is clearly identified with the words “POTABLE WATER” with letters suitably large and clear, such as at least 1.25 cm (0.5 in) high.

The potable water pump needs the capacity for service demands, and to prevent contamination the pump should not be used for any purpose other than for pumping potable water. The installation of a stand by pump is recommended for emergencies, such as breakdown in the main unit serving the potable water system.

Hand pumps, which are installed on some ships to serve galleys and pantries for emergency or routine use as a supplement to pressure outlets, need to be so constructed and installed as to prevent the entrance of contamination into the potable water storage tank or into the water being

To prevent contamination, the potable water pressure tank should not be cross-connected to non-potable water tanks through a main air compressor. Where a common compressed air system supplies pressure to both non-potable and potable water non-pneumatic tanks, the air supply to tanks needs to be through a failsafe devise, such as press on type of air valve and hose. A press on air valve is one that must be held in place manually.

It is advisable in support of traceability that fittings and appliances be marked legibly and permanently with the manufacturer's designation or name in order to readily provide identification of the product at any time.

Capacity

In providing adequate storage for potable water, consideration needs to be given to the size of the ship’s complement of officers and crew, the maximum number of passengers accommodated, the time and distance between ports of call with approved water sources, and the availability of water suitable for treatment with facilities aboard. Sufficient storage is needed to preclude the need for treating overboard water from heavily contaminated areas, and to allow time for maintenance and repair.

The amount of storage may be decreased if the potable-water supply can be supplemented by water purified aboard, but only by such an amount as can be supplied dependably by the purification process.

The treatment of water from heavily contaminated areas can be avoided by loading from approved shore sources while in port, or by treatment of water from wash-water tanks that have been filled from satisfactory sources. In the latter case, total storage requirements can be made up of a combination of wash-water storage and potable-water storage, but in no case should the potable-water storage be less then a reasonable baseline to allow for treatment system failures, such as a 2-day supply.

Location and design

The tank would ideally be independent of the shell of the ship, unless the bottom of the tank is a suitable distance, such as at least 60 cm (2 feet) above the maximum-load water-line and all shell seams and connections are continuously welded on the inside of the tank. There would ideally be no rivets in that part of the shell or shell connections that form the side of the tank. A suitable protection from contamination, such as a 45 cm (18 in) cofferdam above and between tanks that are not for storage of potable water and also between the tanks and the hull, is recommended. Skin or double-bottom tanks are not generally acceptable for potable water storage.

A deck may be used as the top of a potable-water tank, provided that contamination risks are controlled by avoiding access or inspection openings therein, and that the deck seams are continuously welded or joined on the inside of the tank.

The bottom of any potable-water tank which is located in the lower part of the ship would need to be a suitable distance, such as at least 45 cm (18 in), above the top of inner-bottom tanks used for the storage of liquids. When an operating deck, platform or grating is installed in the vicinity of the potable-water tank and near the inner-bottom plating, it is preferable that the bottom of the potable-water tank be above such operating deck, platform or grating. In the absence of inner-bottom plating, the bottom of the potable-water tank should be a suitable distance, such as at least 45 cm (18 in) above the lowest point of the bilge space (not a sump or drain-well). The bottom of a potable water tank may be formed by the inner-bottom plating if:

- a suitable distance, such as 45 cm (18 in), deep void space exists underneath;
- there is no way for the void to be filled; and
- the void space and the inner-bottom plating around the tank are provided with means for adequate drainage.

If the material of which a tank is constructed should require coating, such coating should not render the water stored therein toxic or otherwise unfit for human consumption. Ideally, written documentation should be provided that the coating is approved for use in potable water tanks and that all manufacturer's recommendations for application and drying or curing of the coating have been followed. It's important to coat all items that penetrate the tank (e.g., bolts, pipes, pipe flanges) with the same product used for the tank's interior to protect water quality and tank integrity.

Ideally, no drain-line or pipe carrying non-potable liquids should pass through the tank unless a tunnel of acceptable construction is provided. Tunnels should be made suitable materials such as heavy plate and should be placed on a continuous slope for drainage purposes, and the pipe therein should be adequately robust, such as of extra-heavy steel with butt-welded joints. Potable water lines inside a potable water tank should ideally be jointless and corrosion-resistant to reduce risk of damage arising. To help prevent cross-contamination, lines carrying sewage or other highly contaminated liquids should not pass directly over the manhole in the tank. Lines above tanks should ideally not have any mechanical couplings and all welded pipes over the tank would need to be treated in order to make them corrosion-resistant. If coaming is present along the edges of the tank, it is advisable to provide slots along the top of the tank to allow leaking liquid to run off and be detected.

Manholes

The potable-water tank would need to be provided with a manhole giving access for cleansing, repair and maintenance. It may be located on the side, where flush-type construction is acceptable. When located in the top, even if this is formed by the deck, it would need to be provided with a coaming, or curb, raised a suitable distance, such as at least 1.25 cm (0.5 in) above the top of the tank. The manhole cover would need to extend to the outer edge of the curb and be provided with a gasket and tightly fastened in place to avoid contamination entry. A hinged or slip-on cover is not recommended because of possible contamination from overflow, drainage or wash-water entering the tank.

Vents

Every potable water storage tank will need to be provided with a vent so located and constructed as to prevent the entrance of contaminating substances and vectors. A single pipe may be used as a combined vent and overflow. A potable water tank vent should not be connected to the vent of any tank holding or intended for holding non potable liquid since such a connection may lead to contamination. The vent or combined vent and overflow should terminate with the open end pointing downward and should be screened with a mesh corrosion resistant screen to keep out contamination and vectors, such as 16-mesh or finer.

The vent might end at the side of the tank near the bottom of the ship, with the opening above normal bilge level and readily inspectable otherwise, the open end should be a suitable distance, such as at least 45 cm (18 in), above a weather deck in a sheltered space. If the end must be exposed to wave action, it would typically be equipped with a back-water (check) valve to prevent contamination entry.

The vent needs to be adequately sized. For example, the combined cross-sectional area of the vent and overflow can be made equal to or greater than the cross-sectional area of the filling line to the tank, unless the tank is provided with a relief valve (instead of an overflow pipe). In the latter case, the vent pipe would still need to be or reasonable size, such as at least 3.8 cm (1.5 in) in diameter.

To help prevent cross-contamination, it is important that the potable-water-tank vent not be connected to the vent of any tank holding or intended for holding non-potable liquid.

Overflows

It is important that the potable-water tank be provided with an overflow or relief valve, which should be so located that the test head of the tank is not exceeded. The overflow can be constructed and protected in the same manner as recommended for vents. An overflow may be combined with a vent, but the provisions described for the construction and protection of both vents and overflows should be observed.

Water-level gauges

Any means provided for determining the depth of water in the potable water tanks would need to be so constructed as to prevent the entrance of contaminated substances or liquids into the tanks. Examples of suitable devices include:

- water- gauge glass with shut-off valve on a side of the tank;
- petcocks at appropriate intervals on the side of the tank;
- petcocks installed in a vertical, offset pipe that is connected to the tank near the bottom, returned to top of tank or ends in a screened gooseneck;
- water-level indicators actuated by air pressure (the air may supplied by a hand-pump, or an independent compressor, or through a “press-on” valve with a liquid trap installed in the supply line from the main compressed-air system);
- an enclosed float gauge; and
- a water-operated pressure gauge.

Drains

The potable water tank should be designed so that it can be completely drained in case there is a need to dump the water to remove contamination. The drain opening should be sufficiently large, such as at least 3.8 cm (1.5 in) in diameter, ideally the same diameter as that of the inlet pipe. When drainage is by gravity flow, the opening can be in the bottom of the tank and can terminate flush with or below the inner surface of the tank bottom. The installation can be such as to avoid a reinforcing plate, a raised welding bead, or a protruding pipe or surface that would prevent complete drainage. When the suction line of the potable-water-pump is used to drain the tank, it should drain so as to control contamination, such as from a sump. To control contamination risks, the drain in the pump-discharge line can be so located ahead of any branch take-off to the distribution system. A valve can be installed on the main immediately beyond the drain-line take-off. When a suction line is used only for the potable water distribution system, it can be placed a suitable distance, such as at least 15 cm (6 in), from the tank bottom or sump bottom.

A screw-plug or capped nipple can be installed on a tank drain only where it is easily accessible and where the water can be wasted directly therefrom. When a pipe-drainage system is installed, it is best to be make it independent of all other drainage systems, and protected, to control contamination risks**.** Unless a locking type valve is provided, the drain-line can be plugged or capped, in order to prevent the loss of water in case the drain valve should become loosened by vibration.

Safe water pumping

Mechanical pumps

The potable-water pump should have adequate capacity for service demands to help maintain positive system pressure, and should not be used for any purpose other than for pumping potable water to help prevent contamination. The installation of a stand-by pump is recommended for emergencies, such as a breakdown in the main unit serving the potable-water system. The pumps and the distribution lines need to be of sufficient size that pressure will be maintained at all times and at levels adequate to operate all equipment.

Hand-pumps, which are installed on some ships to serve galleys and pantries for emergency or routine use as a supplement to pressure outlets, would need to be so constructed and installed as to prevent the entrance of contamination into the potable-water storage tank or into the water being pumped. Pump-heads with slotted tops, or pitcher-type pumps, are best not installed.

Pumps should ensure continuous operation when required to maintain pressurisation, for example by priming automatically. A direct connection from the pump should be used, not an air gap, when supplying to a potable water tank.

Pneumatic pumps and pressure tanks

To prevent contamination, potable-water pressure tanks should not be cross connected to non-potable-water tanks through a main air compressor. One of the following devices can safely be used for supplying compressed air to the pressure tank:

- a “snifter” (air intake) air valve on the potable-water pump;
- an independent compressor;
- a main compressed-air system using a press-on valve with a liquid trap installed in the supply line (the liquid trap being installed in the line leading directly to the pressure tank, and being not less than a suitable size, such as 5 cm (2 in) in diameter and 20 cm (8 in) in length; and
- any other device that will prevent contamination of the potable water.

Where a common compressed-air system supplies pressure to both non-potable and potable water pneumatic tanks, the air supply to tanks should be through a failsafe press-on type of air valve and hose. A press-on air valve is one that must be held in place manually.

Safe water distribution

To help control cross-connection risks, potable water piping should ideally not pass under or through sewage or tanks holding non-potable liquids. The distribution lines should not be cross-connected with the piping or storage tanks of any non-potable water system. Potable water lines should ideally be located so that they will not be submerged in bilge water, nor pass through tanks storing non-potable liquids. Distribution lines, including the suction lines of the potable-water pump, should not be cross-connected with the piping or storage tank of any non-potable-water system. There would typically be no blind or spectacle flanges, nor any removable or swing sections of pipe in the lines, whereby such a connection can be made. Where a cross-connection has been made, and liquids, including non-potable water, have entered the potable-water system, the entire system would typically be disinfected.

Selection of service pipe and plumbing materials, and their correct installation, are important in controlling the microbial and chemical quality of water at the point of supply. If the material of which a pipe is constructed should require coating, such coating should not render the water stored therein toxic or otherwise unfit for human consumption.

If hot water piping and cold water piping are laid side by side close together, appropriate thermal insulation would typically be carried out to prevent warming or cooling of the respective pipes and the possibility of bacterial growth. Similarly, cold, potable water would typically not be used for cooling boiler water for testing purposes, unless it is either supplied to or discharged from the cooler through an air gap or other means of thermal separation.

To encourage use of the safe, potable supply, potable-water outlets would typically be provided in convenient locations, such as near passenger, officer and crew quarters, and in the engine and boiler rooms. To support food safety, hot and cold potable water would typically be supplied under pressure to the galley, pantry and scullery. Steam to be applied directly to food would typically be made from potable water. Boiler steam is a safe means of heating potable water and food if applied indirectly, as through coils, tubes or separate chambers. Hot and cold potable water would typically be supplied under pressure to the hospital and other medical-care spaces for hand washing and medical-care purposes (but not necessarily for hydrotherapy, toilet or bedpan flushing). Only potable water would typically be piped to the freezer for making ice for drinking purposes.

Back flow prevention

When potable water is delivered to non-potable systems and supplied under pressure, the system would need to be protected against backflow by either backflow preventers or air gaps. If backflow preventers fail, negative pressure can arise and this can lead to ingress of contaminants into the system.

The ship should have a comprehensive program that provides safe connections to the potable water system through air gaps or appropriate backflow devices at high hazard locations if present, such as:

- potable water supply lines to swimming pools, whirlpools, hot tubs, bathtubs, showers, and similar facilities;
- photographic laboratory developing machines;
- beauty and barber shop spray rinse hoses;
- barbage grinders;
- hospital and laundry equipment;
- air conditioning expansion tanks;
- boiler feed water tanks;
- fire systems;
- toilets;
- freshwater or saltwater ballast systems;
- bilge or other waste water locations;
- international shore connection; and
- any other connection between potable and non potable water system.

In summary, all non-potable connections to the potable water system shold use appropriate backflow prevention (e.g., air gaps, reduced pressure principal backflow prevention assemblies, pressure vacuum breakers, atmospheric vacuum breakers, pressure type backflow preventers, or double-check valves with intermediate atmospheric vent).

Backflow preventers should be located so that they may be serviced and maintained when required since testing and maintenance of such devices is often necessary. If reduced pressure principle backflow prevention assemblies are used, a test kit would typically be provided for testing the devices annually.

Vacuum breakers should be installed in supply lines to the discharge side of the last control valves a suitable distance, such as at least 10 cm (4 in), above the flood-level rim of fixtures, or in accordance with critical distances approved by the health administration of the country where the ship is registered.

An air gap is the unobstructed distance, measured vertically, between the lowest point of the delivery fixture and the flood-level rim of the receiving receptacle. Typically, this air gap would typically be at least twice the diameter of the delivery fixture opening and at minimum 25 mm (1 in).

Air gaps are preferred for the delivery of potable water to waste-disposal units, hospital equipment, some equipment used in preparing or processing food, and equipment for the washing of eating and drinking utensils. A back flow preventer may be used when an air gap is mechanically impracticable or when water under pressure is required. When neither an air gap nor a vacuum breaker on the discharge side of the control valve is practicable, for example on a drinking-glass rinser or similar flow-through unit, a suitably sized, such as 3.8 cm (1.5 in) or larger, waste drain, located below the water inlet at a point at least twice the diameter of the water-supply pipe, is satisfactory, provided that the discharge occurs through an air gap close to the unit. Direct connections of the potable-water system to the jackets of coffee urns and steam kettles are satisfactory. The delivery of potable water to non-potable-water systems, and to sinks, wash-basins, bath-tubs, laundry tubs and trays, clothes washing machines, autoclaves, or similar receptacles, should be made through an air gap.

To avoid back pressure, there should not be any direct connection between the potable-water system and aspirators, ejectors or other hydraulically-operated devices, or water system for the cooling of machinery. For similar reasons, hot-water-heating systems or air-conditioning circulating-water systems should not be supplied from the potable-water system unless the circulating system is closed, has no other water connections, and the water is not used for heat exchange in units containing toxic materials. Furthermore, individual air gaps should be placed in the drain-lines from water-bath sterilizers, hospital water stills, autoclaves, and all hospital and food-handling equipment that may be subject to less than atmospheric pressures.

Pressure-type backflow preventers (e.g., carbonator backflow preventer) or double-check valves with intermediate atmospheric vents prevent both backsiphonage and backflow caused by back pressure and are best used in continuous pressure-type applications.

Where potable water is directed to a black water tank for rinse down or other such use, it should only be connected through an air gap. Even reduced pressure principle backflow prevention assemblies are considered inadequate in such a high hazard condition.

Suitable identification and marking

Potable water piping should be clearly identifiable to help prevent cross-connection plumbing errors, for example by being painted blue or striped with light blue bands or a light blue stripe at fittings on each side of partitions, decks and bulkheads. Markings need to be suitably frequent, such as at intervals not exceeding 5 m in all spaces except where the décor would be marred by such markings. Potable water outlets would typically be labelled, such as by using the words "POTABLE WATER". Similarly, non-potable outlets would typically be labelled, such as by using the words "UNFIT FOR DRINKING". If the direction of flow is important, this can be shown by means of an arrow pointing in the respective direction. Additional marking to differentiate between hot and cold water may be necessary in some cases. When potable water is produced aboard the ship by treatment of non-potable water, the identifying markers of the piping system would typically begin at a point beyond the last treatment unit. When disinfection, including superchlorination and dechlorination, is involved in the treatment process, the markings would typically begin immediately following disinfection. When any disinfection process requiring a retention tank is used, the piping beyond the retention tank would typically be marked. The bodies of valves installed in that part of the potable-water system which is marked would typically be appropriately labelled.

Drinking fountains

Water jet orifices from drinking fountains need to be slanted and the orifice needs to be protected by a cover to prevent contamination. Drinking fountains should ideally have stainless steel cabinets in food preparation areas. Bowls or basins of drinking fountains and coolers should be constructed of suitable, such as impervious, non-oxidizing, material, and so designed and constructed as to be easily cleaned and protected against back flow. In general, the orifice should be clear of the rim of the basin, such as by at least 2 cm (0.75 in). The water-supply pipe may need to be provided with a pressure-regulating valve that will enable the user to regulate the flow of water. To avoid spillage and pooling, which may support pests, the waste opening and pipe should be of sufficient size to carry off the wastewater rapidly, and would typically be provided with a strainer. The drain would typically be fitted with a trap, if it is connected to a drainage system. To ensure operability and hygiene, the water-contact surfaces of drinking fountains must be kept clean.

Water-service containers must be kept thoroughly clean to control microbial growth. Coolers that permit direct contact between ice and water and coolers in which water bottles are inserted neck downwards into the cooling chamber are not permitted recommended as they are not easy to keep in hygienic condition under ship conditions.

Safe water treatment

Treatment facilities should be so designed that they are suitable for the water to be purified and capable of ensuring efficient operation with the production of potable that conforms to the *Guidelines for drinking-water quality 2004* (WHO 2004a) or any relevant authority's requirements. Since using safe water sources is the first barrier in drinking water safety management, overboard water that is to be treated on ships should be taken from areas relatively free from pollution wherever possible, including consideration being given to aerial pollution. It is best not to install, or remove if installed, by-passes around treatment units, except where necessary as part of the treatment process. A sufficient supply for replacement of any vital or fragile parts of the treatment apparatus should be available provided with the ship.

Halogenation

Halogenation in this context is the disinfection of water using halogen disinfectants, such as chlorine, bromine or iodine. Halogen dosing should be highly reliable. For example, dosing would typically be controlled by a flow meter or analyzer. Ideally, pH adjustment would typically be included for water bunkering and production. The analyzer, controller, and dosing pump would typically be designed to accommodate changes in flow rates. Best practice is to provide a completely automatic halogenation system that is controlled by the analyzer. The halogenation probe would measure free halogen and be linked back to the analyzer/controller and dosing pump. A back-up halogenation system should ideally be provided, because even momentary lapses in disinfection can lead to outbreaks, with a switch over that automatically begins pumping halogen when the primary (in-use) pump fails to provide adequate halogenation.

Some means of continuously recording the halogen dose, such as an analyzer-chart recorder or electronic data logger with ≤ 15 min polling intervals, should ideally be included, to provide a record of disinfection system performance. The analyer should be located at a suitable point, such as at a distant point in the system where significant water flow exists. The analyzer would typically measure and indicate free halogen, e.g. that which is available for disinfection, in the range 0 to 5 mg/L. An audible alarm in a continually occupied watch station, e.g., the engine-control room, would ideally be set up to indicate low free-halogen readings at this distant-point analyzer.

A sample cock should ideally be located at a suitable distance, such as at least 3 m (10 feet) downstream of the halogen injection point, to allow measurement of the halogen dosed and verify readings from the analyzer.

Disinfection by chlorination

Disinfection of the water, whether regular or intermittent, would typically be accomplished by methods approved by the relevant national health administration. When chlorine is the accepted disinfectant, the procedure recommended in the following paragraphs is typical of what should be used.

The chlorine should preferably be applied in form of a hypochlorite solution, using a commercial hypochlorinator designed for the purpose. It is desirable to apply the chlorine in direct proportion to the flow-rate of the water being treated. Therefore, an automatic, proportional-control hypochlorinator should ideally be used. The device should ideally be constructed or equipped so that the flow of the hypochlorite solution may be observed. Its capacity should be determined on the basis of the maximum rate of flow of water and the treatment required to produce a satisfactory chlorine residual (typically around 0.5 to 1 mg/L of free chlorine or 1.0 mg/L of chloramines as water enters the distribution or storage system).

Chlorine requires a contact time to be effective. When water is treated regularly by chlorination, provision may need to be made for a baffled holding tank of sufficient capacity to provide a suitable contact period for the chlorine and water. This period of contact should end before any water is delivered to the next treatment unit or the distribution system, and should be computed on the basis of maximum rate of flow through the contact tank. When a normal dosage of chlorine is used, the contact period would typically be at least 30 minutes, with a final free chlorine residual of at least 0.5 mg/L. When superchlorination is practiced, a shorter period of contact may be satisfactory.

The use of liquid chlorine presents a hazard from escaping gas and the space requirements for the acceptable installation and operation of equipment and storage of reserve cylinders are considerable.

Filtration

Filtration can be used when it is necessary as part of a purification system that includes disinfection. Faucet filters and other types of terminal filters often collect and accelerate the growth of bacteria. The storage and manual insertion of replaceable filter elements may be a means of introducing contamination. Because of these potential health hazards, the use of terminal filters is discouraged unless some means are provided for disinfecting the filtering media immediately after insertion and periodically thereafter, or unless the unit is of the type that utilizes replaceable cartridges.

Filters that have been designed and constructed to meet the requirements of the national health administration or the local health authority of the country of registration are recommended for installation. These filters should be so installed, tested and inspected that they will produce a satisfactory effluent at all times, provided the instructions for their operation and maintenance are strictly followed.

Distillation

A distilling plant that supplies water to the potable-water system would need to be of such design that it will produce potable water regularly. Provision would need to be made in the evaporator to prevent flooding and to minimize foaming or carry-over of water into the distiller condenser. The steam coil or tubes in the evaporating chamber, and the cooling coils in the distiller condenser and the condensate cooler, would need to be arranged to facilitate inspection for corrosion, pitting or leaks.

For a plant that will produce water for both non-potable-water and potable-water systems, the distillate can be supplied to the potable-water tank and distribution systems by means of a permanent connection. Distillate connections elsewhere can be by means of an air gap or reduced pressure principle (RP) backflow assembly. An L-shaped swing connection between the distillate-discharge piping or distillate tanks and the potable-water system is not generally considered acceptable protection. The seawater inlets (sea chests) can be located forward of all overboard wastewater and ballast tanks discharge outlets. When air gaps are provided in the discharge lines to all non-potable-water systems, a direct connection may be made to the potable-water system.

The manufacturer's operating instructions would typically be posted near the distillation plant to help support sound operations by crew.

Examples of good design practices associated with some types of distillation units include:

- *High-pressure units*. Distilling plants operating at atmospheric pressure or above, in which the discharge line is connected to the potable-water system, are provided with a means of discharging the distillate to waste in case it should not be fit for use.

- *Low-pressure units*. Low-pressure or partial vacuum distillation plants, which operate at pressures lower than atmospheric in the boiling chambers, are so designed that they will consistently convert sea water into water containing not more than 4.3 mg/L of salinity (sea salts) (1/4 grain per USG). A plant of this type would be equipped with a low-range electrical salinity indicator for determining the salinity of the distillate at a point beyond the final condensate cooler. A flow-diversion valve would be provided to divert the flow of water from the potable-water tanks when the salinity of the distillate exceeds 4.3 mg/L of salinity (sea salts) (1/4 grain per USG). This valve would operate instantaneously, and be controlled by a salinity cell. The electrical control for this valve would be so arranged that the valve will operate regardless of the position of the selector switch on the salinity indicator panel, and the flow of water would be diverted from the potable-water tank when the current is off. In addition, an alarm would be provided to warn the operator when the salinity of the condensate exceeds the limit.

- When evidence of the dependability of a low-pressure plant to produce water of required salinity under operating conditions is lacking, or when fresh-water or brackish-water feed is used, one of the following measures can be taken:
  - design the system to maintain a temperature of 73ºC (165ºF or 346ºK) or higher in the boiling chamber;
  - provide for heating the distillate to 73ºC (165ºF or 346ºK) or higher; and
  - provide facilities for adequate chlorination of the distillate.

10.2.3 Non-potable water

To keep things simple and reduce risks of contamination due to confusion, it is desirable, whenever practicable, to have one single system supplying potable water for drinking, culinary uses, dish-washing, ablutionary, hospital and laundry purposes. However, ships in commercial service may have two or three water systems: sanitary, potable and wash-water.

Wash-water supply

A wash-water system, when installed, can be used to supply slop sinks, laundry facilities, water-closets, bibcock connections for deck flushing purposes, heated water for dish-washing and water for other special uses as indicated. Often the wash-water may be used to replenish the potable-water supply after proper treatment.

Storage tanks

Wash-water storage tanks shall be so constructed and protected as to prevent the possibility of contamination in a similar way to potable water. Under common practice, double-bottom, fore and aft peak, wing, and topside tanks, and tanks with partitions common with other tanks containing non-potable liquids, are considered satisfactory, provided that they are not crossed by sanitary drains, have covered manholes protected in the same manner as for potable-water tanks, and have all sounding tubes capped or plugged. When a deck forms the top of a wash-water tank, all openings are typically curbed and covered as required for potable-water tanks. Adequate protection against back flow, drainage or discharge of bilge or contaminated water or wash would also be provided.

Distribution system

The wash-water system would not be cross-connected to the fire system or systems carrying bilge water or other contaminated liquids. When it is necessary to transfer water quickly from one tank to another, a connection to the ballast system is permitted, provided that the suction and discharge lines and manifolds to the ballast pumps that draw from or discharge to the wash-water tanks are independent of the suction and discharge manifolds or lines of the wash-water pumps. Water contaminated by this procedure must be disinfected and properly treated before being used.

The suction line of the wash-water pump must be located above normal bilge-water level. Drains from wash-water tanks or any part of the wash-water system, and discharges to fixtures or systems handling sewage or other contaminating wastes, must be protected against back flow. Wash-water may be piped into hospital or other medical-treatment spaces for use in hydrotherapy, and for any other use except drinking, food-preparation, hand-washing and medical care.

Wash-water may be used for food-refuse grinders, provided that the delivery line is protected against back flow, and is properly identified. Wash-water would not be piped into galley, pantry, scullery or other food-preparation areas for food-preparation and dish-washing purposes. However, in ships where heat-treated wash-water is used for the washing of utensils, this use may be continued if the water is heated to not less than 77ºC (170ºF or 350ºK) before leaving the heater.

Wash-water may be piped to food-preparation, food-serving and dish-washing areas for deck-flushing purposes, provided that outlets are a suitable distance, such as not more than 45 cm (18 in), above the deck and posted with signs reading, for example, “FOR DECK-WASHING ONLY”.

Wash-water faucets

The use of potable water only for ablutionary purposes is recommended. Where wash-water is used, the hot and cold water lines to a public wash-basin would typically terminate in a single outlet for mixing hot and cold water, as described for potable water, to control proliferation of bacteria in warm water. If the wash-basin is provided with a drain-plug, it should be thoroughly washed before and after use and a notice to this effect should be posted near the basin. Any faucets on the wash-water system would typically be clearly marked with signs, such as reading “UNFIT FOR DRINKING”. Bath-tub inlets, shower heads and bibcock connections in shower spaces or in public bathrooms need not be so labelled. Where faucets for potable water and wash-water may be located adjacent to one another and may not be identified otherwise, the potable-water outlet would typically be clearly labelled with words such as “POTABLE WATER”.

Sanitary or overboard -water system

System and distribution

The sanitary or overboard-water system, including all pumps, piping and fixtures, should be completely independent of the potable-water and wash-water systems. There should not be any cross-connections, direct or indirect, between the sanitary system and these systems.

All faucets and outlets on the sanitary system shall be clearly labelled with signs reading something like “UNFIT FOR DRINKING”. Since its quality is not controlled, overboard water would typically not be piped to galley, pantry, food-storage or food-preparation areas unless the supplies of potable water and wash-water are limited. Outlets for overboard water in any food space would typically be labelled such as “UNFIT FOR DRINKING - FOR DECK-WASHING ONLY: DO NOT USE WHILE IN HARBOUR”, and would typically be not more than a suitable distance, such as 45 cm (18 in), above the deck, to avoid confusion and inappropriate use.

Water from the sanitary system may be piped to food-refuse grinders not located in food spaces. Outlets from the sanitary system into hospital or other medical-treatment spaces may be used only for flushing waste-disposal units, such as toilets, bed-pan washers and slop sinks.

Salt-water baths

To control cross-contamination, salt-water service to bath-tubs and showers would typically be independent, with no cross connections to either potable-water or wash-water systems. The supply line for this service would typically originate at a point in the overboard system where adequate flushing of the service line will occur between the time the vessel leaves the harbour, or polluted area, and the time water will be drawn for bathing purposes. Adequate flushing may be best assured if the service line originates at or near the pump. A shut-off valve can be installed to prevent operation of the service to the baths while the ship is in polluted waters. This valve can be installed just beyond the point of take-off from the main overboard system, and can be labelled with words such as “KEEP CLOSED WHILE IN CONTAMINATED WATERS”.

10.3 Food safety

As perhaps the most important cause of disease outbreaks aboard ship, design features that help to protect food safety are important contributors to passenger and crew health. In general, adequate well-constructed and well-lit facilities are required for the safe preparation, handling, serving and storage of food and beverages. Equipment and facilities need to be located, designed and constructed to ensure that:

- contamination is minimized;
- design and layout permit appropriate maintenance, cleaning and disinfection and minimize airborne contamination;
- surfaces and materials, in particular those in contact with food, are non-toxic for the intended use, suitably durable, easy to maintain and clean and, where necessary, disinfect;
- where appropriate, suitable facilities are available for temperature, humidity and other controls; and
- there is effective protection against pest access and harbourage.

The internal design and layout of galleys and food storage areas need to permit good food hygiene practices, including protection against cross contamination. Structures within galleys need to be soundly built of durable materials and be easy to maintain, clean and disinfect.

In particular the following good practices are typical where necessary to protect the safety and suitability of food:

- the surfaces of walls and partitions would be made of impervious materials with no toxic effect in intended use;
- walls and partitions would have a smooth surface up to a height appropriate to the operation;
- the decks or flooring of all spaces would be constructed to allow adequate drainage and cleaning. The bottoms of shaft wells in these spaces would be so constructed and maintained as to permit ready access for cleaning;
- bulkheads and deckheads would be constructed and finished to minimize the build up of dirt and condensation, and the shedding of particles;
- pipes in unsheathed deckheads over spaces where food is stored, handled, prepared or served, or where utensils are washed, would be insulated if condensation forms or is likely to form;
- drainage lines carrying sewage or other liquid waste would not pass directly overhead or horizontally through spaces for the preparation, serving, or storage of food, or the washing of utensils;
- deck drains would be provided in all spaces where flooding -type cleaning is practised or where water or liquid is discharged in to the deck. They would be provided with water-seal traps, except where drainage is directly overboard. Drains from refrigerated spaces would be protected against backflow;
- windows would be easy to clean, be constructed to minimize the build up of dirt and where necessary, be fitted with removable and cleanable insect proof screens;
- doors would be self-closing and have smooth, non absorbent surfaces, and be easy to clean and, where necessary, disinfect; and
- working surfaces that come into direct contact with food would be in sound condition, durable and easy to clean and maintain and disinfect. They would be made of smooth, non-absorbent materials, and inert to the food, to detergent and disinfectants under normal operating conditions.

10.3.1 Safe equipment and utensils

It is good practice to ensure the equipment and containers coming into contact with food are designed and constructed to ensure that, where necessary, they can be adequately cleaned, disinfected and maintained to avoid the contamination of food. Equipment and containers would typically be made of materials with no toxic effect in intended use. Where necessary, equipment would need to be durable and movable or capable of being disassembled to allow for maintenance, cleaning, disinfection, monitoring and, for example, to facilitate inspection for pests.

Depending on the nature of the food operations undertaken, adequate facilities need to be available for heating, cooling, cooking, refrigerating and freezing food, for storing refrigerated or frozen foods, monitoring food temperatures, and when necessary, controlling ambient temperatures to ensure the safety and suability of food. Equipment used to cook, heat, treat, cool, store or freeze food can be designed to achieve the required food temperatures as rapidly as necessary in the interests of food safety. Such equipment can include design features to allow temperatures to be monitored and controlled.

Containers for waste, by products and inedible or dangerous substances, can be made specifically identifiable, suitably constructed and where appropriate, made of impervious material. Waste containers used in the galley can be provided with foot-operable lids, be emptied frequently and be easy to clean and disinfect.

All sinks, dish washing machines, food preparation machines, meat grinders, counters, cupboards, drawers, shelves, racks, tables, can openers, butcher's equipment, meat-blocks, cutting boards, pastry boards, knife racks, stoves, hoods, any machinery housed in spaces for the preparation and serving of food, and all food-contact surfaces and equipment can be so constructed as to be easily cleaned and disinfected, if necessary, and kept clean and in good repair.

10.3.2 Safe facilities

Safe water

An adequate supply of potable water with appropriate facilities for its storage and distribution is required to be available whenever necessary to ensure the safety and suitably of food. Non potable water (e.g. seawater) would typically have a separate system and would typically not be supplied to the galley unless essential, as discussed along with the management of the reticulated potable water on ship under Chapter 2.

Sufficient cleaning and disinfecting facilities

To protect food safety, design criteria for adequate facilities can be adopted in constructing systems for cleaning food, utensils and equipment. Such facilities need an adequate supply of hot and cold potable water. Personnel hygiene facilities need to be readily available to encourage an appropriate degree of personal hygiene and to avoid contaminating food. Facilities to be located beside the galley can include (see also Section 10.3.7):

- adequate means of hygienically washing and drying hands, including wash basins and a supply of hot and cold water;
- lavatories of appropriate hygienic design with handbasins, which do not open directly into galleys or other food handling areas. An adequate supply of soap and hand drying facilities at handbasins; and
- adequate changing facilities for personnel including suitable storage facilities for clothes.

Adequate ventilation

Adequate means of natural or mechanical ventilation help to support safe food operations. Ventilation systems can be designed and constructed so that air does not flow from contaminated areas to clean areas and, where necessary, they can be adequately maintained and cleaned. Louvers or registers at ventilation terminals can be made readily removable for cleaning. Particular attention would be given to:

- minimising air-borne contamination of food, for example, from aerosols and condensation droplets;
- controlling ambient temperatures; and
- controlling humidity, where necessary, to ensure the safety and suitability of foods.

Adequate lighting

Adequate natural or artificial lighting helps to enable operation in a hygienic manner. The intensity would be made adequate according to the nature of the operation. Lighting fixtures can, where appropriate, be protected to ensure that food is not contaminated by breakage.

Adequate storage

The long term and improper storage of provisions on board seagoing vessels can be a hazard as they are frequently carried for many weeks or even months and the vessel can be subject to extreme climatic influences. Appropriate facilities and storage of perishable foods may also be a problem on many cargo ships. Storage, especially in cold stores, in an unpacked condition might have an adverse effect on provisions. See also Section 10.8.1.

The type of storage facilities required will depend on the nature of the food. Separate and secure storage facilities for cleaning materials and hazardous substances can be provided. Adequate facilities for the storage of food, ingredients and non-food chemicals (e.g. cleaning materials, lubricants, and fuels) can be provided. Food storage facilities can be designed and constructed to:

- permit adequate maintenance and cleaning;
- avoid pest access and harbourage;
- enable food to be effectively protected from contamination during storage; and
- provide an environment which minimizes the deterioration of food (e.g. by temperature and humidity control).

Sanitary food contact areas

Food contact surfaces should ideally be free of open seams, cracks or crevices and easily cleanable. Exposed bolts, nuts, threads, screw heads and rivets are not generally acceptable on food contact surfaces. Corners formed by joining the sides of food contact surfaces can be built with a radius of curvature that helps cleaning, such as at least 3 mm (0.25 in). On coved corners of food contact surfaces the coved radius can be sufficient to help cleaning, such as at least 1.6 mm (0.125 in). Soldered and welded areas on food contact surfaces need to be smooth and durable to allow cleaning and avoiding cracks. The deposit metal can be well-finished to eliminate sharp angles, cracks or crevices that may harbour hazardous agents.

Food areas need to be protected against the leakage or seepage of lubricants or other extraneous or foreign substances. Sound deadening or undercoating material is not generally applied to the surface of equipment that is directly above an area where exposed food is kept as this material may harbour hazards.

Drawers and bins that come into contact with food can be made readily removable and easily cleanable to support cleansing. For the same reasons, they can be made free of open seams or cracks, and finished smooth on all sides. Covers, insets, or receptacles for unpackaged food or beverages can be made readily removable or designed for easy cleaning *in situ*.

Suitable non-food contact areas

Exposed non-food contact surfaces can also be designed to reduce risks of indirectly contaminating food by being free of open seams, cracks or crevices. Equipment housing or component parts can be made free of openings into inaccessible areas where food, liquid or dust may enter and insects may shelter. Mixers, refrigerators, compressors and similar units, if provided with openings or louvres, can contain readily removable inspection ports or panels.

Deck mounted equipment can be installed with the base flush with the deck (openings and joints sealed), or a minimum suitable clearance of, for example, 15 cm (6 in), being provided between the lowest horizontal framing member of the equipment and the deck to facilitate easy cleaning. This also applies when equipment is mounted on an island or curbing. Control mechanisms, couplings and other components mounted on the housing of the equipment can be so designed and installed as to preclude the entrance of dirt and vermin and the formation of inaccessible areas which may prevent proper cleaning and inspection.

Horizontal openings on top of food storage cabinets can be protected by a coaming around their periphery. The minimum height of this coaming needs to be sufficient, such as 5 mm (0.2 in) measured from the surface of the cabinet or from the overflow level. Openings in work tables or dish tables to food refuse and waste receptacles can have a watertight turned-down edge extending a suitable distance, such as at least 1.25 cm (0.5 in) below the table surface, unless the opening is provided with a scrap block. Exposed edges and nosings on horizontal surfaces, such as tops of dressers, tables and shelves, can have turned-down or return flanges with a suitable space of, for example, at least 2 cm (0.75 in) between the sheared edge and the frame angles, or they should be totally enclosed.

Hoods over steam kettles, ranges and other cooking units can have smooth, easily cleanable interiors. Gutters, if provided, can be designed and dimensioned to facilitate cleaning. Filters, if used, can be so installed as to direct drippings into gutters. Baffles, vanes, dampers and other air-control facilities can be readily accessible or removable. Sea-rails on cooking ranges can be removable and easily cleanable.

Exposed refrigerant coils located in food compartments can be of a finless type and arranged so as to allow thorough cleaning. Blower-type or fin-type evaporators can be enclosed or shielded to protect them from spillage of food and to protect the food from condensate drip. Enclosed-type refrigeration evaporators can be provided with condensate drains. Refrigerant and water coils in water cooling units can be readily accessible for brush cleaning and provided with plug and drain to facilitate flushing and draining of the water-bath compartment.

Sliding doors on galley and pantry equipment can be removable and their tracks or guides free of inaccessible openings or slots. The lower tracks can be slotted at the ends to facilitate removal of dust and debris. Equipment doors, whether sliding or hinged, can avoid openings into inaccessible areas. If gaskets are used on insulated doors, they can be made easily cleanable and replaceable and should fit tightly. Door catch openings, latches, latch striker plates and other fastening devices can be made free of openings that could permit vermin and debris to enter channels, door panels or other component parts of the equipment. Latches, hinges and other hardware can be fabricated of smooth, easily cleanable material.

Cutting boards can be readily removable for cleaning or easily cleanable without removal. They can be free of open seams or cracks and finished smooth on all sides. Drawers and bins can be readily removable and easily cleanable.

Insulation material can be protected against seepage and condensation. Flashing or closing strips can be made so as not to permit entry of food fragments or debris.

When the area under floor mounted equipment is not entirely enclosed, legs supporting such equipment can be so constructed as to prevent collection and harbourage of dirt, vermin and debris. Bases, curbs or elevated islands for supporting equipment above deck level, if provided with toe space, can be not indented a distance greater than the height of the lowest framing member of the equipment above the deck. Toe space can have a minimum suitable height, such as 5 cm (2 in). Enclosed spaces, such as columns, vertical supports and legs, can be sealed against the entrance of vermin.

Coaming around equipment such as steam kettles can be sealed against seepage, infiltration and the entrance of vermin, and provided with drains having removable strainers. The drain can be located at the lowest point within the area. Drains for galley and sink equipment could be dimensioned as follows:

- sinks: 3.75 cm (1.5 in) minimum diameter; and
- steam tables and bains marie: 2.5 cm (1 in) minimum diameter.

Exposed horizontal drainpipes, including the traps, can be so installed as to permit proper cleaning of the floor area beneath. Such pipes would not ideally be located above areas for the storage, preparation or serving of food.

To help avoid contamination, water inlets to steam tables, kettles and other sink-type equipment can be located a minimum safe distance of, for example, twice the diameter of the water inlet, and in any case not less than 2.5 cm (1 in), above flood level rim. If the water supply line is required to be below that, vacuum breakers of an acceptable type and properly installed can be fitted (see section 10.2.1 for details).

Shelves used as false bottoms can be made readily removable or sealed in place to preclude the entrance of food fragments and vermin to the space beneath. Silverware containers can be removable and so designed and fabricated as to permit immersion in sanitizing solutions, or water at 82ºC (180ºF or 355ºK). Dipper wells for ice cream dippers can be equipped with running water from an above-the-rim inlet and constructed of smooth, seamless material.

10.3.3 Food processing equipment

Equipment requirements

The following is a checklist of the sort of equipment that might be required, depending on the level, and type of service, in galleys and recommended for other areas:

- Blast chillers incorporated into the design of passenger and crew galleys. More than one unit may be necessary depending on the size of the vessel, the unit's intended application, and the distances between the chillers and the storage and service areas.
- Food preparation sinks in as many areas as necessary (i.e., in all meat, fish, and vegetable preparation rooms; cold pantries or garde mangers; and in any other areas where personnel wash or soak food). An automatic vegetable washing machine may be used in addition to food preparation sinks in vegetable preparation rooms.
- Storage cabinets, shelves, or racks for food products, condiments, and equipment in food storage, preparation, and service areas, including bars and pantries.
- Portable tables, carts, or pallets in areas where food or ice is dispensed from cooking equipment, such as from soup kettles, steamers, braising pans, tilting skillets, or ice storage bins. Provide a storage cabinet or rack for large items such as ladles, paddles, whisks, and spatulas.
- Knife lockers that are easily cleanable and meet food contact standards.
- Storage areas, cabinets, or shelves for waiter trays.
- Dishware lowerators or similar dish storage and dispensing cabinets.
- An adequate number of work counters or food preparation counters that provide sufficient work space.
- Drinking fountains.
- Cleaning lockers.

The main pot washing area(s) serving a full galley operation, would typically have at a minimum, a three-compartment sink with a pre-wash station or a four-compartment sink with an insert pan and an overhead spray. The sink design needs to allow for handling the largest piece of equipment used in the areas being served. Automatic warewashing machines with separate pre-wash stations may be used in addition to the three compartment sinks, provided the machines are sized to the equipment being washed. A pass-through type warewashing machine is preferable to an undercounter model.

Depending on the size of facilities and distance to central pot washing facilities and other factors, heavy-use areas such as bakeries, butcher shops, and other preparation areas may require a three-compartment sink with a pre-wash station or a four-compartment sink with an insert pan and an overhead spray. All food preparation areas are likely to need easy access to a three compartment utensil washing sink or a warewashing machine equipped with a dump sink and a pre-wash hose.

Beverage dispensing equipment typically requires readily removable drain pans, or built in drains in the tabletop. Bulk milk dispensers would need to have readily removable drain pans to enable cleaning of potentially hazardous milk spillages. A utility sink is desirable in areas such as beverage stations where it is necessary to refill pitchers or dispensers or discard liquids such as coffee. Ice cream, sherbet, or similar product dipper wells ideally need to be provided with running water and proper drainage. Condiment dispensing equipment would usually have readily removable drip pans.

Clean storage areas need to be sufficient to house all equipment and utensils used in food preparation areas such as ladles and cutting blades. The design of all installed equipment needs to direct food and wash water drainage into a deck drain scupper, or deck sink, and not directly or indirectly onto a deck.

For openings to ice bins, food display cases, and other such food and ice holding facilities, tight fitting doors or similar protective closures are desirable to prevent contamination of stored products.

Countertop openings and rims of food cold tops, bains-marie, ice wells, and other drop in type food and ice holding units can be protected with, for example, a raised integral edge or rim of 5 mm (0.2 in) or more above the counter level around the opening.

Suitable materials

Food contact areas

The materials used for food contact surfaces need to be suitable, for example, being corrosion resistant, non-toxic, non-absorbent, easily cleanable, smooth and durable. This applies especially to heating units in contact with food, cooking fats, oils or similar cooking media. Cutting boards should be of a suitable material, such as one equivalent to or better than select hard maple. Materials other than those already accepted and listed for use as food contact surfaces or containers should be approved by the relevant national health administration before installation.

Solder or welding material used on food contact surfaces need to be chosen so as not to create toxic effects in food. For example, materials typically contain no more than 5% of lead, and no cadmium or other substances known to be toxic either by themselves or in combination with other ingredients, are used. The manufacturer of any material intended for food contact use can be asked to attest to its safety by signing a statement indicating that the material is non-toxic. This statement can be sent to the national health administration for verification if required.

Non-food contact areas

Materials used for non-food contact surfaces can be made to be durable and readily cleanable. Welding materials used in welding together non-corrosive materials can be selected so as to render the weld area corrosion resistant.

In general, paint is unsuitable to be applied to either non-food contact surfaces or food contact surfaces.

10.3.4 Installation

All permanently installed or stationary equipment needs to be installed and constructed with flashing to exclude openings hidden by adjacent structures or other equipment, unless adequate clearance for proper cleaning is provided. As an example, a minimum clearance of 15 cm (6 in) is recommended under leg-mounted equipment between the lowest horizontal framing member of the equipment and the deck, or the equipment can be mounted as described in the last paragraph of this section.

It is important to ensure that counter mounted equipment, unless portable, is either sealed to the tabletop or mounted on legs. Once gain, to facilitate cleaning, counter-mounted equipment should have sufficient clearance, typically at least 7.5 cm (3 in), between the lowest horizontal member and the counter top. There is also a need to provide access behind counter-mounted equipment, including beverage line equipment, for cleaning.

The clearance between the back of enclosed equipment, such as ranges and refrigerators, and the bulkhead should be governed by the combined length of the items. For example, for equipment up to 61 cm (2 ft) long, a suitable clearance might be at least 15 cm (6 in); for longer equipment the clearance might be proportionally greater, up to a maximum of 61 cm (2 ft) for equipment 245 cm (8 ft) or more in length. If the space between equipment and bulkhead is readily accessible from one end, the above clearances could be halved; with 15 cm (6 in) being a suitable minimum, unless the equipment is mounted as stated in the last paragraph of this section.

If two items of equipment, such as ovens or ranges, are located near each other, the space between them needs to be adequate to enable cleaning, as described in the previous paragraph. Alternatively, the space between them could be effectively closed on all sides by tightly fitting spacers.

When mounting equipment on a foundation or coaming, there is a need to consider the foundation or coaming and ensure an adequate separation distance above the finished deck, at least 10 cm (4 in) may be sufficient. Cement or a continuous weld can be used to seal equipment to the foundation or coaming. A sealed-type foundation or coaming for equipment can be provided if not mounted on legs. The overhang of the equipment from the foundation or coaming can be made not excessive, for example, not to exceed 10 cm (4 in). To avoid possible vermin habitat, it is advisable to completely seal any overhang of equipment along the bottom.

Equipment installed without adequate clearances, such as those suggested in the previous paragraphs, can have the spaces under, next to and behind them effectively enclosed and sealed to deck and/or bulkhead. Penetrations such as cable, conduit or pipe openings, can be provided with tightly fitting collars or other closure fittings made of materials acceptable to the relevant national health administration.

Electrical connections, pipelines and other attached equipment

Electrical wiring from permanently installed equipment can be encased in durable and easily cleanable material. The use of braided or woven stainless steel electrical conduit outside of technical spaces or where it is subject to splash or soiling is not recommended, unless encased in easily cleanable plastic or similar easily cleanable material. It is possible to adjust the length of electrical cords to equipment that is not permanently mounted or fasten them in a manner that prevents the cords from lying on countertops.

Other bulkhead- or deckhead-mounted equipment such as phones, speakers, electrical control panels, or outlet boxes can be sealed tight with the bulkhead or deckhead panels. Such items can be kept away from areas exposed to food splash.

It is possible to tightly seal any areas where electrical lines, steam, or water pipelines penetrate the panels or tiles of the deck, bulkhead or deckhead, including inside technical spaces located above or below equipment or work surfaces. In addition, any openings or void spaces around the electrical lines or the steam or water pipelines and the surrounding conduit or pipelines can be sealed.

Steam and water pipelines to kettles and boilers in stainless steel cabinets can be sealed or pipelines positioned behind bulkhead panels. The number of exposed pipelines can be minimized. Any exposed, insulated pipelines with stainless steel or other durable, easily cleanable material can be covered.

10.3.5 Spaces for the storage, preparation and service of food

Decks

The decks, or flooring, of all spaces where food or drink is stored, handled, prepared, or where utensils are cleaned and stored, can be so constructed as to be easily cleaned and kept clean at all times. Surfaces can be smooth and kept in good repair. The bottoms of shaft wells in these spaces can be so constructed and maintained as to permit ready access for cleaning and inspection.

Provision rooms, walk in refrigerators and freezers, and transportation corridors

To comply with good practice, use hard, durable, non-absorbent decking, e.g. tiles, or diamond plate corrugated stainless steel deck panels in refrigerated provision rooms. Cove all bulkhead and deck junctures with, for example, a 10 mm (0.4 in) radius and seal tight. If a forklift will be used in this area, reinforce stainless steel panels sufficiently to prevent buckling. Painted steel decking is acceptable in provisions passageways, transportation corridors, and drystore areas.

Galleys, food preparation rooms, and pantries

It is possible to construct decks from hard, durable, non-absorbent, non-skid material. Installation can include durable coving with adequate radius, such as at least a 10 mm (0.4 in), or open design, such as > 90 degrees, as an integral part of the deck and bulkhead interface and at the juncture between decks and equipment foundations. Stainless steel or other coving, if installed, can be of sufficient thickness so as to be durable and securely installed. All deck tiling can be sealed with a durable, water-tight grouting material. Stainless steel deck plate panels can be sealed with a continuous, non-corroding weld. In technical spaces below undercounter cabinets, counters or refrigerators, the deck can be a durable, non-absorbent, easily cleanable surface such as tile or stainless steel. Painted steel and concrete decking is not recommended. All openings where piping and other items penetrate through the deck can be sealed.

Food service areas

It is advisable to ensure that all buffet lines have hard, durable, non-absorbent decks that are a suitable width, such as at least 1 m (3 feet), measured from the edge of the service counter or from the outside edge of the tray rail, if such a rail is present. The dining room service stations can have a hard, durable, nonabsorbent deck, e.g., sealed granite or marble, with a safe separation distance of, for example, at least 60 cm (2 feet), from the edge of the working sides of the service station. The decks behind service counters, under equipment, and in technical spaces can be constructed of hard, durable, non-absorbent materials, e.g., tiles, epoxy resin, or stainless steel. Painted steel and concrete decking is not recommended. Durable coving suitable radius, such as at least a 10 mm (0.4 in), or open design > 90 degrees can be used as an integral part of the deck and bulkhead interface and at the juncture between decks and equipment foundations. Stainless steel or other coving, if installed, needs to be of sufficient thickness so as to be durable and securely installed. Durable linoleum tile or durable vinyl deck covering is only recommended in staff, crew or officers' dining areas. Ideally, all bulkhead and deck junctures (including deck/buffet, deck/bar, deck/waiter station) will have coving of suitable radius, such as 10 mm (0.4 in), and be sealed tight.

Bulkheads and deckheads

Bulkheads and deckheads of spaces in which food and drink are stored, prepared or handled, or in which utensils are stored or cleaned, can have smooth, hard-finished, light-coloured, washable surfaces.

Fibrous insulation or similar materials can be sheathed so as to prevent particles of the insulating materials from falling on foods. Cloth or plaster surfacing is not generally acceptable for satisfactory protection. Fibrous air filters are not recommended to be installed in the deckheads or over food processing equipment.

Perforated acoustic material is not recommended in galleys, pantries, sculleries and other food handling or food storage spaces. It is acceptable for use in dining rooms, provided that the material is of such a nature, or is so sheathed, as to prevent particles from falling on food through holes and seams.

Provision rooms, walk in refrigerators and freezers, and transportation corridors

It is advisable to provide tight-fitting stainless steel bulkheads in walk in refrigerators and freezers and line doors with stainless steel. Painted steel is acceptable for provision passageways, transportation corridors, and in drystores areas. Light colours are recommended to reveal any dirt. Stainless steel panels are preferable for dry storage areas. Bumper guards are recommended to protect bulkheads from forklift damage in areas through which food is stored or transferred. It is good practice to close deckhead mounted cable trays, piping or other difficult to clean deckhead mounted equipment, or completely close the deckhead.

Galleys, food preparation rooms, and pantries

Bulkheads and deckheads, including doors, door frames, and columns, can be constructed with a high quality, corrosion resistant stainless steel. The gauge would need to be thick enough so that the panels do not warp, flex, or separate under normal conditions. For seams that can be so sealed, such as greater than 1 mm (0.04 in) but less than 3 mm (0.125 in), it is common practice to use an appropriate sealant. For bulkhead and deckhead seams too large to be so sealed, such as greater than 3 mm (0.125 in), stainless steel profile strips are recommended. All bulkheads to which equipment is attached needs to be of sufficient thickness or reinforcement to allow for the reception of fasteners or welding without compromising the quality and construction of the panels. Utility line connections need to be installed through a stainless steel or other easily cleanable food service approved conduit that is mounted away from bulkheads for ease in cleaning. Back splash attachments need to be sealed to the bulkhead with a continuous- or tack-weld and polish. An appropriate sealant is required to make the back splash attachment watertight. All openings can be sealed where piping and other items penetrate the bulkheads and deckheads, including inside technical compartments.

Food service areas

Bulkheads and deckheads may be constructed of decorative tiles, pressed metal panels or other hard, durable, non-corroding materials. Stainless steel is not required in these areas. However, the materials used need to be easily cleanable. All openings where piping and other items penetrate through the deck need to be sealed.

Piping in deckheads

Pipes in unsheathed deckheads over spaces where food is stored, handled, prepared or served, or where utensils are washed, can be insulated if condensation forms, or is likely to form, on them.

Drainage lines carrying sewage or other liquid waste can be diverted from passing directly overhead or horizontally through spaces for the preparation, serving, or storage of food, or the washing of utensils. Where such drainage lines exist, they can be free of clean-out plugs and flanges, or these can be closed by welding. Exceptions in existing installations may be made where the lines do not leak, drip, or spray non-potable liquids on food and utensils. Drainpipes passing through insulation surrounding refrigerated spaces are considered acceptable.

10.3.6 Sanitation of spaces for storing, preparing and serving food

Water supply

To avoid contamination, only potable water, hot or cold, should be piped into the spaces where food is stored, prepared, or served, except as indicated in the following two paragraphs. If only cold potable water is piped into these spaces, adequate facilities need to be installed for cleaning and bacterial treatment of dishes and utensils.

Drainage

To provide adequate drainage, deck drains are needed in all spaces where flooding type cleaning is practised or where water or liquid wastes are discharged on to the deck. They need to be provided with water-seal traps, except where drainage is directly overboard. Drainage gutters are acceptable, except behind and beneath equipment. Gutter-ways may be provided with easily cleaned and removable plates of perforated metal or of heavy, flat expanded metal.

Drain lines from all fixtures, sinks, appliances, compartments, refrigeration units, or devices that are used, designed for, or intended to be used in the preparation, processing, storage, or handling of food, ice, or drinks can be connected to appropriate waste systems by means of an air gap or air-brake. Stainless steel or other easily cleanable rigid or flexible material can be used in the construction of drain lines, and size drain lines appropriately. A sufficient minimum interior diameter is needed, such as 2.5 cm (1 in), for custom built equipment. Drain lines are needed to minimize the horizontal distance from the source of the drainage to the discharge. Horizontal drain lines need to be of sufficient clearance, such as at least 10 cm (4 in), above the deck and slope to enable drainage.

Drain lines from evaporators can be sloped and extended through the bulkheads or decks. Drain lines can be directed through an accessible air gap or air break to a deck scupper or drain below the deck level or to a scupper outside.

All drain lines (except condensate drain lines) from hood washing systems, cold top tables, bains-marie, dipper wells, food preparation sinks and warewashing sinks or machines can be designed in accordance with suitable practices, such as the following examples:

- drain lines can be kept quite short, e.g. less than 1 m (3 feet), and free of sharp angles or corners, if designed to be cleaned in place by a brush;
- drain lines can be made readily removable for cleaning, if quite long, such as greater than 1 m (3 feet); and
- drain lines can be designed to drain through an air break or air gap to a drain or scupper.

When possible, installed equipment drain lines can extend in a vertical line to a deck scupper drain. When this is not possible, the horizontal distance of the line can be kept to a minimum. Handwashing sinks, mop sinks and drinking fountains are not required to drain through an air break or air gap.

Lighting

To ensure adequate illumination for safe food working, surfaces where food is prepared, or where utensils are cleaned, should be provided with sufficient illumination, with 200 lux or more being considered adequate when equipment is installed. A minimum light level, such as 110 lux, is recommended even behind equipment to allow effective cleaning. This standard of illumination does not apply to the dining room. In bars and dining room waiters’ stations designed for lowered lighting during normal operations, more lighting, such as 220 lux, is recommended during cleaning operations.

For equipment storage, garbage and food lifts, garbage rooms, and toilet rooms, sufficient lighting is required, such as 220 lux of lighting at a distance of 76 cm (30 in) above the deck. Lighting levels need to be adequate, such as at least of 220 lux, in provision rooms when measurements are taken while the rooms are empty. Lighting levels need to be sufficient, such as at least 110 lux, during normal operations when foods are stored in the rooms.

For effective illumination, it is useful to place the deckhead mounted light fixtures above the work surfaces and position them in an "L" pattern rather than a straight line pattern. Light fixtures need to be installed tightly against the bulkhead and deckhead panels and electrical penetrations sealed completely to allow easy cleaning around the fixtures. Light shields on light fixtures need to be shatter-resistant, and removable, so that they completely enclose the entire light bulb or fluorescent light tube(s).

Light bulbs need to be shielded, coated, or otherwise shatter-resistant in areas where there is exposed food, clean equipment, utensils, and linens, or unwrapped single-service, and single-use articles. Infrared or other heat lamps need to be protected against breakage by a shield surrounding and extending beyond the bulb so that only the face of the bulb is exposed. Decorative track or recessed deckhead-mounted lights above bar countertops, buffets, and other similar areas may be mounted on or recessed within the deckhead panels without being shielded. However, the bulbs installed in these light fixtures need to be the specially-coated, shatter-resistant type.

Ventilation and hood systems

All spaces in which food is prepared or stored, except cold storage spaces, should be ventilated adequately to be free of odours and condensation. Natural ventilation can be supplemented, as needed, by mechanical ventilation systems. Louvers or registers at ventilation terminals can be readily removable for cleaning. Wing nuts or snap-on devices are recommended for the fastening of louvres and registers on the terminals. Racks for stowage of cooking vessels and utensils can be placed away from being under ventilation hoods to avoid debris.

Hood systems or direct duct exhaust can be installed over warewashing equipment (except undercounter warewashing machines) and over three-compartment sinks in pot wash areas where hot water is used for sanitizing to reduce condensation. For warewashing machines with direct duct exhaust, such exhaust can be directly connected to the hood exhaust trunk where hot water is used for sanitization.

Where installed, it is important to design exhaust hoods over warewashing equipment or three-compartment sinks with sufficient overhand, such as a minimum of 15 cm (6 in), from the edge of equipment so as to capture excess steam and heat. Hood systems can be installed above cooking equipment to ensure that they adequately remove excess stem and grease-laden vapours. Hood systems or dedicated local ventilation can be installed to control excess heat and steam from bains-marie or steam tables.

Warewashing machines can be set up with direct duct exhaust to the ventilation system with a clean-out port in each duct located between the top of the warewashing machine and the hood system or deckhead. The flat condensate drip pans located in the ducts from the warewashing machines can be removable for cleaning.

Adequately sized exhaust and supply vents are required and can be positioned and balanced appropriately for expected operating conditions to ensure proper air conditioning, and capture and exhaust of heat and steam. The system can be tested for this after installation.

Where filters are used, it is worth ensuring that they are readily removable and cleanable. Vents and duct work needs to be accessible for cleaning. Hood washing systems are recommended for removal of grease generated from cooking equipment.

Stainless steel with coved corners can be used that provides sufficient radius, such as at least 10 mm (0.4 in), to construct hood systems. Continuous welds or profile strips can be used on adjoining pieces of stainless steel. A drainage system is not required for normal grease condensate or cleaning solutions applied manually to hood assemblies. Drainage systems are required for hood assemblies using automatic clean in-place systems.

Provision evaporators and drip pans

Evaporators located in the walk in refrigerators, freezers, and dry stores need to be constructed with stainless steel panels that cover piping, wiring, coils, and other difficult-to-clean components. The evaporator drip-pans need to be constructed of stainless steel, have coved corners, are sloped to drain, are of sufficient strength to maintain slope, and are readily accessible for cleaning. Non-corroding spacers can be placed between the drip pan brackets and the interior edges of the pans.

A heater coil can be provided for freezer drip pans and attached to a stainless steel insert panel or to the underside of the drip pan. The panel can be easily removable for cleaning of the drip pan. Heating coils can be provided for drain lines installed inside of the lines. Refrigeration condensate drip pans can be positioned and sized to ensure catchment of drippage from the entire surface area of the evaporator unit. Thermometer probes can be encased in a stainless steel conduit and placed in the warmest part of the room where food is normally stored.

Food display protection

To help prevent dissemination of disease, it is necessary to provide effective means to protect food (e.g. sneeze shields or display cases) in all areas where food is on display for consumption. Sneeze guards can be designed around the following criteria:

- Sneeze guards may be temporary (portable), built in, permanent, and integral parts of display tables, bains-marie, or cold-top tables.
- Sneeze guard panels can be durable plastic or glass that is smooth and easily cleanable. Sections of manageable lengths can be removable for cleaning.
- Sneeze guards can be positioned in such a way that the sneeze guard panels intercept the line between the consumer's mouth and the displayed foods Factors such as the height of the food display counter, the presence or absence of a tray rail, and the distance between the edge of the display counter and the actual placement of the food can be taken into account.
- Side protection on sneeze guards is required if the distance from the food is quite short, such as less than 1 m (3 feet), from where people are expected to pass.

Tray rail surfaces can be sealed, coved, and easily cleanable in accordance with guidelines for food splash zones.

Beverage delivery system

A stainless steel, vented, double-check valve backflow prevention device can be installed in all bars that have carbonation systems, e.g., multiflow beverage dispensing systems. The device can be installed before the carbonator and downstream from any copper or copper-alloy (e.g. brass) in the potable water-supply line. The supply lines to the dispensing guns can be encased in a single tube. If the tube penetrates through any bulkhead or countertop, it is possible to seal the penetration with a grommet.

Bulk dispensers of beverage delivery systems can incorporate in their design a clean in-place system that provides a means of flushing, and sanitizing the entire interior of the dispensing lines in accordance with manufacturers' instructions.

Disease vectors

All spaces where food and drink are stored, handled, prepared and served can be so constructed and maintained as to exclude rodents and vermin (see section 10.6). Flying insects can be excluded from spaces for the storage, handling, preparation and serving of food, especially when a ship is in port. All openings between food spaces and the outer air can be effectively protected with screens of non-corrosive wire or plastic cloth, 16-mesh or finer. Door screens can be tight fitting.

Either the inlet or outlet to ventilation ducts for food spaces can be similarly screened, except that forced-draft ventilation openings do not require insect screening. Tight fitting self-closing louvres are preferable for covering forced-draft exhaust openings.

10.3.7 Toilet and washing facilities

Adequate toilet facilities for food handling personnel can be placed readily available near food preparation spaces to encourage personal hygiene and sanitation. On smaller vessels, these facilities may be shared by the crew. Such facilities need to be accessible at all times.

To avoid contamination, preferably, toilet rooms would not open directly into spaces where food is prepared, stored or served. Where such toilets exists, the doors need to be tight fitting and self-closing. Wherever possible, there would be a ventilated space between the toilet rooms and the food spaces.

Adequate hand washing facilities need to be provided within or adjacent to toilet rooms, and need to include hot and cold running water from a single mixing outlet, single-service paper or cloth towel dispenser or drying device, suitable soap or detergent or other acceptable cleansing agent, and signs over the basin reading, for example, "WASH HANDS AFTER USING TOILET - WASH BASIN BEFORE AND AFTER USING". Signs warning personnel to wash hands after using the toilet should also be conspicuously posted on the bulkhead adjacent to the door of the toilet.

The following areas can also be provided with similar hand washing facilities, with signs located above basins reading, for example, "WASH HANDS OFTEN - WASH BASIN BEFORE AND AFTER USING":

- Central commissariat - additional wash basins may be needed depending upon distance, partitions, size of spaces and number of employees served, and other impediments to convenient use of facilities.
- Individual galleys, pantries, bakery spaces, butcher spaces, vegetable preparation rooms and sculleries - a single washbasin may serve more than one such area if easily accessible to each area.

Where a common washbasin serves both a food handling space and a toilet for food handlers, a sign reading as above can be posted above it. On ships where hand washing facilities exist in a food service employees' stateroom, easily accessible from the food handling spaces, additional facilities are not required in the food handling spaces. In such cases, individual cloth towels for food handlers are acceptable. Scullery sinks, slop sinks, laundry tubs, dishwashing sinks and similar facilities cannot be used for hand washing. Wash water may be used at washbasins provided that the water is heated to a temperature of 77ºC (170ºF or 350ºK). Only potable water should be used for the cold water supply to wash basins.

10.3.8 Warewashing

Rinse hoses for pre-washing are recommended in some areas, although they are often not required in bar and deck pantries. In all food preparation areas, adequate space is needed for trash cans, garbage grinder, or pulper systems. Grinders are optional in pantries and bars. If a sink is to be used for prerinsing, a removable strainer may be needed.

For soiled landing tables with pulper systems, the pulper trough needs to extend the full length of the table and slope toward the pulper to help take away waste. The back edge of the soiled landing table can be sealed to the bulkhead, or sufficient clearance, such as a minimum of 45 cm (18 in), can be provided between the table and the bulkhead. Soiled landing tables can be designed to drain waste liquids and to prevent contamination of adjacent clean surfaces.

To prevent water from pooling, it is possible to equip clean landing tables with across-the-counter gutters with drains at the exit from the machine and sloped to the scupper. A second gutter and drain line can be installed if the length of table is such that the first gutter at the exit from the machine does not effectively remove pooled water. The length of drain lines can be minimised and when possible, placed in straight vertical lines with no angles.

Pulper wiring can be encased in a durable and easy to clean stainless steel or nonmetallic watertight conduit and raised sufficiently, such as at least 15 cm (6 in), above the deck. All warewashing machine components can be elevated sufficiently, for example, at least 15 cm (6 in), above the deck to provide for drainage.

Removable splash panels can be provided from stainless steel to protect the pulper and technical areas. Grinder cones, pulper tables, and dish-landing tables can be constructed from stainless steel with continuous welding. Platforms for supporting warewashing equipment can be constructed from stainless steel, avoiding the use of painted steel.

Warewashing machines can be designed and sized for their intended use and installed according to the manufacturer's recommendations. Warewashing machines using chemical sanitizers can be equipped with a device that indicates audibly or visually when more chemical sanitizer needs to be added.

Warewashing machines can have an easily accessible and readable data plate. The plate, affixed to the machine, can include the machine's design and operating specifications and the following:

- temperatures required for washing, rinsing, and sanitizing;
- pressure required for the fresh water sanitizing rinse unless the machine is designed to use only a pumped sanitizing rinse;
- conveyor speed for conveyor machines or cycle time for stationary rack machines; and
- chemical concentration (if chemical sanitizers are used).

Three-compartment warewashing, and potwashing sinks can be sized correctly for their intended use. Sinks can be made large enough to submerge the largest piece of equipment used in the area that is served. Sinks can have coved, continuously welded, internal corners that are integral to the interior surfaces.

One of the following arrangements can be used to prevent excessive contamination of rinse water with wash water splash:

- an across-the-counter gutter with a drain dividing the wash compartment from the rinse compartment;
- a splash shield of sufficient height above, such as 10 cm (4 in), the flood level rim of the sink between the wash and rinse compartments; or
- an overflow drain in the wash compartment sufficiently below, such as 10 cm (4 in), the flood level.

Hot water sanitizing sinks can be equipped with accessible and easily readable thermometers, a long-handled stainless steel wire basket, or other retrieval system and a jacketed or coiled steam supply with a temperature control valve to control water temperature. Three-compartment sinks that utilize halogen for the sanitization step do not require the aforementioned items necessary for hot water sanitizing sinks.

Three-compartment warewashing sinks with a separate pre-wash station can be provided for the main galley, crew galley, lido galley and other full-service galleys with pot-washing areas. For meat, fish, and vegetable preparation areas, there can be at least one three-compartment sink or an automatic warewashing machine with a pre-wash station. Warewashing facilities that are accessible to all food preparation areas, such as the bakery and pantries, can be provided.

Sufficient shelving for storage of soiled and clean ware can be provided. As an example, the storage available for soiled ware can be approximately on third the volume provided for clean ware. Either solid or open tubular shelving or racks can be used. Solid overhead shelves can be designed so that they drain at each end to the landing table below.

Adequate ventilation is required to prevent condensation on the deckhead or adjacent bulkheads. Any filters installed over warewashing equipment need to be easily removable for cleaning.

10.3.9 Disposal of refuse

Provision should be made for the sanitary storage and disposal of refuse to avoid disease-causing organisms and vectors proliferating. Refuse cans may be used in food preparation areas and sculleries, for immediate use only. Storage of refuse cans, filled and empty, can be in a designated space separate from food handling operations and so constructed and maintained as to be rodent- and vermin-proof and easily cleaned. Holding bins may likewise be used, provided they are constructed of impervious, readily cleaned materials, and fitted with tight fitting covers to make them inaccessible to rodents and vermin. Cans containing refuse can be tightly covered at all times, except during actual use in food handling areas.

Where refuse cans are used, a space separate from the food handling spaces and adjacent to the refuse can storage space can be provided for cleaning them. This space can be equipped with scrubbing brushes, cleansing agents, steam or hot water under pressure, and a hose fitted with an adjustable nozzle.

Food refuse grinders or disposal units located in sculleries or other food handling area can be filled with potable water only, supplied through inlets into the hoppers or grinder bodies. Salt water eductors may be used in these food spaces, in the horizontal discharge line from such grinders or disposal units. Salt water or wash water supplies may be used in food refuse grinders installed in areas other than food spaces. All feed-chute openings can be fitted with closures to be kept closed at all times when a grinder is operating, except for the swinging door which is opened to push refuse into the grinder. Acceptable vacuum breakers or air gaps can be installed in the water supply lines to grinders that are flushed with potable water or wash water.

10.4 Recreational water environments

Pool design needs to be tailored to a realistic understanding of the way that the pool will be used. For example, the number and type of users, temperature of use and any special health considerations for particular user groups will all affect the details of how the pool should be designed, constructed and managed. Specific considerations might include:

- the daily opening hours;
- the peak periods of use;
- the anticipated number of users; and
- special requirements such as temperature, lanes and equipment.

Swimming and bathing pool water needs to be hygienically safe. These water quality requirements need to be met through optimal matching of the following design factors:

- design of the correct pool hydraulics (to ensure optimal distribution of disinfectant throughout the pool);
- installation of the appropriate treatment system (to remove particulate pollutants and disinfectant-resistant microorganisms); and
- installation of a disinfection system (to inactivate infectious microorganisms so that the water cannot transmit and propagate disease-causing microbiological agents); and
- inclusion of systems to add fresh water at frequent intervals (to dilute substances that cannot be removed from the water by treatment).

Pools on ships need to be of safe design, as with land pools. The source water may be either seawater or from the potable water supply for the ship. The hydraulic and circulation system of pool will necessitate a unique design, depending upon ship size and pool location. The filtration and disinfection systems will require adaptation to the water quality.

Types of pools

Swimming pools and similar recreational water environments may be located either outdoors, indoors or both. They may be supplied with fresh (surface or ground), marine or thermal water (i.e. from natural hot springs). They may be supervised or unsupervised. They may be heated or unheated.

For the purposes of this guide swimming pools, hot tubs and plunge pools are considered together under the general heading of recreational water environments and include whirlpools and spa pools. The following types of pools are considered:

- Fill and draw swimming pools are not recommended on ships.
- Recirculating swimming pools, which can be equipped and operated to provide maximum health and safety protection for swimmers. Recirculating swimming pools need to provide adequate circulation, such as complete circulation of the water within the pool, with replacement of the water every 6 hours, or less during pool operation.
- The flow through swimming pool is generally the type most practicable for construction, installation and operation aboard ships. The pool and its water supply needs to be designed, constructed and operated in view of the health and safety protection of bathers.
- Spa systems on passenger vessels need to allow for adequate shock dosing or super halogenation, such as daily, and allow for routine visual inspection of granular filtration media. The type, design and use of the pool may predispose the user to certain hazards. Bubble pools or whirlpools, for example, may be subject to high bather loads relative to the volume of water. Where there are high water temperatures and rapid agitation of water, it may become difficult to maintain satisfactory pH, microbiological quality and disinfectant residuals. In any pool with concentrated bather loads, pollution can be high. In addition, some special provisions of pools, such as forced recirculation and aeration, may contribute to bacterial overgrowth.

Circulation and hydraulics

The purpose of giving close attention to circulation and hydraulics is to ensure that the whole pool is adequately served. Treated water needs to reach all parts of the pool, and polluted water needs to be removed - especially from areas most used and most polluted by bathers. If not, even good water treatment may not give good water quality. The design and positioning of inlets, outlets and surface water withdrawal are crucial.

Circulation rate is related to turnover period, which is the time taken for a volume of water equivalent to the entire pool water volume to pass through the filters and treatment plant and back to the pool. In principle, the shorter the turnover period, the more frequent the pool water treatment. Turnover periods need to, however, suit the particular type of pool. Ideally, turnover can be designed to vary in different parts of the pool: longer periods in deep areas, shorter where it is shallow.

Bathing load

Bathing load is a measure of the number of people in the pool. All pools need to be designed in view of this and designers need to identify and maintain a realistic relationship between bathing numbers and pool and treatment capacity. For a new pool, the bathing load needs to be realistically estimated at the design stage.

The number of bathers that can use a swimming pool safely at one time and the total number that can use a pool during one day are governed by the area of the pool and the rate of replacement of its water by clean water. Therefore, the pool needs to be designed with special attention to the probable peak bathing load and the maximum space available for the construction of a pool. The many factors that determine the maximum bathing load for a pool include:

- area of water - in terms of space for bathers to move around in and physical activity;
- depth of water - the deeper the water, the more actual swimming there is and the more area a bather requires;
- comfort; and
- pool type and bathing activity.

Filtration

Filtration is crucial to good water quality since if filtration is poor, aesthetic clarity will be affected and disinfection will be impacted. Water clarity is a key factor in ensuring the safety of swimmers. Disinfection will be compromised by reduced clarity, as particles associated with turbidity can surround microorganisms and shield them from the action of disinfectants. In addition, filtration is important for removing *Cryptosporidium* oocysts and *Giardia* cysts and some other protozoa that are relatively resistant to chlorine disinfection.

To remove *Cryptosporidium* oocysts, which are around 4 to 6 µm in diameter, granular media (e.g. sand) filtration needs to follow coagulation because the pore size of a pool sand filter can be as large as 100 µm. Membranes or fine-grade diatomaceous earth filtration can remove oocysts if the porosity of the filter is less than 4 µm.

Some of the factors that are important to consider in the design of a granular media (such as sand) filtration system include:

- Filtration rate: the higher the filtration rate, the lower the filtration efficiency. Some of the higher-rate granular filters do not handle particles and colloids as effectively as medium-rate filters and the cannot be used with coagulants.
- Bed depth: The correct sand bed depth is important for efficient filtration.
- Number of filters: pools will benefit greatly from the increased flexibility and safeguards of having more than one filter. In particular, pools can remain in use with a reduced turnover on one filter while the other one is being inspected or repaired. Filtered water from one filter can be used to backwash another.
- Backwashing: the cleaning of a filter bed clogged with suspended solids is referred to as backwashing. It is accomplished by reversing the flow, fluidizing the sand and passing pool water back through the filters to waste. It should be initiated as recommended by the filter manufacturer, when the allowable turbidity value has been exceeded or when a certain length of time without backwashing has passed. The filter may take some time to settle once the flow is returned to normal and water should not be returned to the pool until it has.

Coagulation

Coagulants (or flocculants) enhance the removal of dissolved, colloidal or suspended material by bringing this material out of solution or suspension as solids (coagulation), then clumping the solids together (flocculation), producing a floc, which is more easily trapped in the filter. Coagulants are particularly important in helping to remove the infective cysts and oocysts of *Cryptosporidium* and *Giardia*, which otherwise would pass through the filter. Coagulant efficiency is dependent upon pH which, therefore, needs to be controlled. Dosing pumps should be capable of accurately dosing the small quantities of coagulant required and adjusting to the requirements of the bathing load.

Disinfection

Disinfection is a process whereby pathogenic microorganisms are removed or inactivated by chemical (e.g. chlorination) or physical (e.g. filtration, UV radiation) means such that they represent no significant risk of infection. Recirculating pool water is disinfected using the treatment process, and the entire water body is disinfected by application of a disinfectant residual, which inactivates agents added to the pool by bathers.

The choice of disinfectant depends on a variety of factors, including compatibility with the source water supply (hardness and alkalinity), bathing load, oxidation capacity, and margin between disinfectant action and adverse effects on human health. Chlorination is the most widely used pool water disinfection method, usually in the form of chlorine gas or sodium or calcium hypochlorite. Ozone in combination with chlorine or bromine is a very effective disinfection system but the use of ozone alone cannot ensure a residual disinfectant capacity throughout the swimming pool.

For disinfection to occur with any biocidal chemical the oxidant demand of the water being treated must first be satisfied and sufficient chemical must remain to effect disinfection.

Choosing a disinfectant

Issues to be considered in the choice of a disinfectant and application system include:

- safety;
- compatibility with the source water supply;
- type and size of pool (disinfectant may be more readily degraded or lost through evaporation in outdoor pools);
- bathing load (sweat and urine from bathers will increase disinfectant demand); and
- operation of the pool (i.e. supervision and management).

The choice of disinfectant used as part of swimming pool water treatment should ideally comply with the following criteria:

- effective, rapid, inactivation of pathogenic microorganisms;
- capacity for ongoing oxidation to assist control of contaminants during pool use;

- a wide margin between effective biocidal concentration and concentration resulting in adverse effect on human health;
- availability of a quick and easy determination of the disinfectants concentration in pool water (simple analytical and test methods); and
- potential to measure the disinfectant's concentration electrometrically to permit automatic control of disinfectant dosing and continuous recording of the values measured.

Commonly used disinfectants include:

- Chlorination is the most widely used pool water disinfection method, usually in the form of chlorine gas or sodium or calcium hypochlorite. Chlorine is inexpensive and relatively convenient to produce, store, transport and use. The chlorinated isocyanurate compounds are somewhat complex white crystalline compounds with slight chlorine-type odour that provide free chlorine when dissolved in water. They are an indirect source of chlorine, via an organic reserve (cyanuric acid). The relationship between the chlorine residual and the level of cyanuric acid is critical and can be difficult to maintain. Chlorinated isocyanurates are not suited to the variations in bathing loads usually found in large public pools. However, they are particularly useful in outdoor swimming pools exposed to direct sunlight where UV radiation rapidly degrades free chlorine.
- Ozone can be viewed as the most powerful oxidizing and disinfecting agent that is available for pool and spa water treatment. However, it is unsuitable for use as a residual disinfectant. It is most frequently used as a treatment step, followed by deozonation and addition of a residual disinfectant, such as chlorine. Excess ozone must be destroyed by an activated carbon filter because this toxic gas could settle, to be breathed by pool users and staff. Residual disinfectants would also be removed by the activated carbon filter and are, therefore, added after this step.
- Like ozone, UV radiation is a plant-room treatment that purifies the circulating water, inactivating microorganisms and to a certain extent breaking down some pollutants by photo-oxidation. This decreases the chlorine demand of the purified water but does not leave a disinfectant residual in the pool water. For UV to be most effective, the water must be pre-treated to remove turbidity-causing particulate matter that prevents the penetration of the UV radiation or absorbs the UV energy.

Dilution

Disinfectant and treatment will not remove all pollutants. The design of a swimming pool should recognize the need to dilute the pool water with fresh water. Dilution limits the build-up of pollutants from bathers (e.g., constituents of sweat and urine) and elsewhere, the by-products of disinfection and various other dissolved chemicals.

Air quality

It is important to manage air quality as well as water quality in swimming pools, spas and similar recreational water environments. Rooms housing spas should be well ventilated to avoid an accumulation of *Legionella* in the indoor air. In addition, ventilation will help reduce exposure to disinfectant by-products in the air.

Showers and toilets

Pre-swim showers will remove traces of sweat, urine, faecal matter, cosmetics, suntan oil and other potential water contaminants. The result will be cleaner pool water, easier disinfection using a smaller amount of chemicals, and water that is more pleasant to swim in.

Pre-swim showers that are separate from post-swim showers are generally preferable. Pre-swim showers can be located en route from changing rooms to the swimming pool. They can be continuous to encourage use. Pre-swim showers need to run to waste. Showers can be provided with water of drinking water quality as children and some adults may ingest the shower water.

Toilets can be provided where they can be conveniently used before entering the pool and after leaving the pool. Users may need to be encouraged to use the toilets before bathing to minimize urination in the pool and accidental faecal releases (AFRs). Babies in particular will need to be encouraged to empty their bladders before they swim.

10.4.1 Swimming pools

Pools usually use seawater, or a potable water supply passing through an air gap or backflow preventer to fill. The fill level of the pool is at the skim gutter level. The pool overflows can either be directed by gravity to the make-up tank for recirculation through the filter system or disposed of as waste. Surface skimmers need to be capable of handling sufficient, such as approximately 80 percent, of the filter flow of the recirculation system. There should be sufficient skimmers, such as at least one skimmer for each 47 m^2 (500 square feet) of pool surface area.

A hair strainer is required between the pool outlet and the suction side of the pumps to remove foreign debris such as hair, lint, and pins etc. The removable portion of the strainer should be corrosion-resistant and have holes that are not too large, e.g. smaller than 6 mm (0.25 in) in diameter.

Filters need to be designed to remove particles at a sufficient rate, such as removing all particles greater than 10 micrometers from the entire volume of the pool in 6 hours or less. Filters can be cartridge or media-type (e.g.; rapid-pressure sand filters, high rate sand filters, diatomaceous earth filters, or gravity sand filters). All media-type filters need to be capable of being back-washed. Provide filter accessories, such as pressure gauges, air-relief valves, and rate-of-flow indicators as required. Provide sufficient access to the sand filters so that they can be inspected at a regular frequency, such as at least on a weekly basis, and the media can be changed periodically.

The make-up tank may be used to replace water lost by splashing and evaporation. If the tank is supplied with potable water, the supply can enter through an air gap or backflow preventer. An overflow line, typically at least twice the diameter of the supply line, and located below the tank supply line may be used.

The use of analyzers helps to automate dosing and optimise conditions for pool safety. Provide automatic dosing of chemicals for disinfection and pH adjustment if required. Water sample points can be provided on the system for the testing of halogen levels and routine calibration of the analyzer. Provide analyzer controlled halogen-based disinfection equipment if required. It may be necessary to ensure that pH adjustment is accomplished by using appropriate acids and bases and that a buffering agent is used to stabilize the pH. Control the injection of acids and bases by an analyzer if required.

The pool mechanical room can be made readily accessible and well-ventilated and a potable water tap can be provided in this room. To help with ongoing maintenance, it is valuable to mark all piping with directional-flow arrows and maintain a flow diagram and operational instructions in a readily available location. The pool mechanical room and re-circulation system need to be designed for easy and safe storage of chemicals and re-filling of chemical feed tanks. Drains need to be installed in the pool mechanical room in order to allow for rapid draining of the entire pump and filter system and that a sufficiently large drain, such as a minimum 8 cm (3 in), is installed on the lowest point of the system.

Children's pools can have their own independent recirculation, filtration and halogenation system because children are particularly potent sources of pathogens. The turn-over rate of water needs to be sufficient, ideally higher than in adult pools, such as at least once every 30 minutes. Anti-vortex type drain covers can be provided that are constructed of durable easily visible, easily cleanable material.

To help reduce drowning risks, the depth of the pool can be displayed prominently so that it can be seen from the deck and in the pool. Depth markers can be labelled either in feet or meters, or both. Additional depth markers can be installed for every significant change of depth, such as 1 m (3 feet), and can be displayed prominently so they can be seen from the deck and in the pool.

Re-circulating pools

Re-circulating swimming pools need to be designed and equipped to provide protection of health and safety for swimmers. The equipment and the operating procedures need to provide complete circulation of the water within the pool at a sufficient frequency, such as replacement of the water every 6 hours, or less, during pool operation. Equipment would usually include filters and other equipment and devices for disinfection and such other treatment as may be necessary to meet the requirements or recommendations of the national health administration of the country of registration. Self-priming, centrifugal pumps are suitable to re-circulate pool water.

Flow-through pools

The flow-through swimming pool is probably the type most practicable for construction, installation and operation aboard ships. The pool and its water supply system need to be designed, constructed and operated to give maximum health and safety protection to the bathers.

The number of bathers that can use a swimming pool safely at one time and the total number that can use a pool during one day are governed by the area of the pool and the rate of replacement of its water by clean water. Therefore, the pool should be designed with special attention to the probable peak bathing load and the maximum space available for the construction of a pool. The following principles should be applied in the design of flow-through pools.

The design capacity of the pool should be judged on the basis of the area, such as 2.6 m^2 (27 ft^2) per bather. For the maintenance of satisfactorily clean water in the pool, the rate of flow of clean water needs to be sufficient to effect complete replacement at sufficient frequency, such as every 6 hours or less. The water flowing through can be delivered to the pool through multiple inlets, located so as to ensure uniform distribution. These inlets can be served by a branch line taking off from the main supply line, at the pressure side of the filling valve near the pool. Control of the flow can be independent of the filling valve.

The overflow can be discharged into scum gutters or a similar boundary overflow, with multiple outlets spaced at suitable intervals, such as not more than 3 m (10 ft) apart, and discharging to the waste system.

A drain can be installed at the lowest point in the pool, and drainage facilities need to be sufficient to ensure quick emptying if required following contamination events. The drains from the pool would preferably be independent, however, when they are connected to any other drainage system, a back-water valve can be installed in the swimming-pool drain-line to stop cross-connections. Anti-vortex type drain covers can be provided, which are constructed of durable easily visible and easily cleanable material. They can also be of such type as to prevent entrapment hazards.

The bottom of the pool can slope toward the drain or drains in such a manner as to effect complete drainage of the water from the pool. In the interest of safety, the slope of the bottom of any part of the pool in which the water is less than a standing depth, such as 1.8 m (6 ft) deep, would not be more than a safe level, such as 1 in 15 gradient. For safety, there should be no sudden change of slope within the area where the water depth is shallow, such as less than 1.5 m (5 ft).

It is preferable to have a separate water-supply system, including the pump. The water intake can be forward of all sewage and drainage outlets from the ship. However, if the pool is to filled and operated only when the ship is under way, the fire or sanitary overboard-water pumps, or a combination of these pumps may be used, noting that the following can be used to reduce contamination risks:

- The delivery line to the pool is independent of other lines originating at or near the discharge of the pump or the valve manifold, or at a point where the maximum or near-maximum flushing of the fire or sanitary-overboard-water pump and main is routinely effected.
- A readily accessible shut-off valve is located close to the point of take-off from the fire or sanitary overboard-water system, and is conspicuously labelled, such as "CLOSE WHILE IN HARBOURS". Overboard water needs not be drawn when the vessel is under way in contaminated waters.

10.4.2 Whirlpool spas

Potable water supplied to whirlpool systems can be supplied through an air gap or approved backflow preventer. Water filtration equipment needs to ensure a sufficient turn-over rate, such as at least once every 30 minutes. Halogenation equipment that is capable of maintaining the appropriate levels of free-halogen throughout the used period can be included.

Filters need to be able to meet requirements, such as being able to remove all particles greater than 10 micrometers from the entire volume of the whirlpool in 30 minutes or less. Filters can be cartridge, rapid pressure sand filters, high-rate sand filters, diatomaceous earth filters or gravity sand filters. A clear sight glass can be added on the backwash side of the filters. It is advisable to design and install filters in a manner that allows for easy access for inspection and maintenance.

All media-type filters need to be capable of being back-washed. Filter accessories, such as pressure gauges, air-relief valves, and rate-of-flow indicators, can be provided. It is best to install systems in a manner that permits routine visual inspection of the granular media filters.

The overflow system can designed so that water level is maintained. It is advisable that whirlpool overflows are either directed by gravity to the make-up tank for recirculation through the filter system or disposed of as waste. Self-priming, centrifugal pumps can be used to recirculate whirlpool water. A hair strainer can be provided between the whirlpool outlet and the suction side of the pumps to remove foreign debris such as hair, lint and pins etc. The removable portion of the strainer need to be corrosion resistant and have no large holes, such as no holes greater than 6 mm (0.25 in) in diameter.

An independent whirlpool drainage system can be provided. If the whirlpool drainage system is connected to another drainage system, a double-check valve between the two can be provided. Drains are needed and the bottom of the whirlpool can slope toward the drains to effect complete drainage. Anti-vortex type drain covers can constructed from durable easily visible, easily cleanable material drains that prevent entrapment hazards.

Provide sufficient skimmers, such as one for every 14 m^2 (150 ft^2) or fraction thereof of water surface area. The fill level of the whirlpool needs to be at the skim gutter level to enable skimming to take effect.

A temperature control mechanism may be required to prevent the temperature from exceeding 40ºC (104ºF or 313ºK) to avoid scalding and overheating.

A make-up tank may be used to replace water lost by splashing and evaporation. If the whirlpool is supplied with potable water, the supply can enter through an air gap or backflow preventer. An overflow line with sufficient size, such as at least twice the diameter of the supply line, and located below the tank supply line may be used.

To help optimising dosing, it is good to provide analyzer controlled chemical dosing for both pH and disinfection. Disinfection is usually accomplished by chlorination or bromination. Water sample points can be provided on the system for the testing of halogen levels and routine calibration of the analyzer. It is advisable to ensure that pH adjustment is accomplished by using appropriate acids and bases and that a buffering agent is used to stabilize the pH. Injection of acids and bases can be controlled by an analyzer. The system needs to permit regular, such as daily, shock treatment or superhalogenation

The whirlpool mechanical room needs to be accessible and well-ventilated and a potable water tap can be provided in this room. All piping can be marked with directional flow arrows and a flow diagram and operational instructions can be provided in a readily available location. The whirlpool mechanical room and recirculation system can be designed for easy and safe storage of chemicals and refilling of chemical feed tanks. Drains can be installed in the whirlpool mechanical room so as to allow for rapid draining of the entire pump and filter system and a sufficient, such as 80 mm (3 in), drain is installed on the lowest point of the system.

10.5 Ballast Water, Liquid and Solid Waste management

10.5.1 Liquid wastes

Sanitary system

Drain, soil and waste pipes need to be of adequate size to prevent clogging and the back flow of sewage or contaminated wastes into the fixtures and spaces served by the collection system.

Overboard discharge of wastes

There are a number of good practices for the design of systems for holding or treatment of liquid wastes.

Wastes requiring treatment

All new ships or ships undergoing major conversion can be equipped with facilities for treating wastes from toilets and urinals, faecal material from hospital facilities and medical care areas, and wastes from food refuse grinders. Holding tanks, properly equipped with pumps and piping, may be installed in place of treatment facilities. Wastes from holding tanks may be discharged to shore connections or to special barges for the reception of these wastes.

The design of treatment facilities and holding tanks can be based on a standard unit, such as 114 L (30 USG), per capita per day. The design and choice of units may need to be approved by the appropriate authority of the country of registration. The design of the interceptors may also need to be approved by the appropriate authority of the country of registration.

Effluent quality

For ships where the normal wastewater flow to be treated is quite large, such as exceeding 4750 L (1250 USG) per day, treatment can be designed to be able to produce an effluent with a suitable quality, such as biochemical oxygen demand (BOD) of 50 mg/L or less, a suspended solids content of 150 mg/L or less, and a coliform count of 1000 or less per 100 ml.

Excess sludge can be stored for appropriate disposal to land-based facilities or when on the high seas.

For ships with a daily flow of waste water to be treated that is quite small, such as less than 4750 L (1250 USG), treatment may be limited to passing the wastes through grinders, followed by disinfection to produce an effluent with a coliform count of 1000 or less per 100 ml.

Chlorination, or an equally effective method of disinfection, may need to be installed to produce an effluent meeting the coliform requirements set by the relevant authorities.

10.5.2 Solid wastes

Facilities for waste disposal

To handle corrosion, the interiors of food and garbage lifts may need to be constructed of stainless steel and meet the same standards as spaces for the storage preparation and service of food. Decks need to be constructed of a durable, non-absorbent, non-corroding material and have a suitable integral cove, for example of at least 10 mm (0.4 in) all along the sides. Bulkhead-mounted air vents can be positioned in the upper portion of the panels or in the deckhead. To help with cleaning and removal of spills, a drain at the bottom of all lift shafts can be provided including provision platform lifts, and dumbwaiters.

If used to transport waste, the interiors of dumbwaiters must be readily cleanable and constructed of stainless steel or similar and meet the same standards that other food service areas must meet. The bottom of the dumbwaiter would need to include a suitable cover, such as a 10 mm (0.4 in) radius.

Garbage chutes, if installed, need to be constructed of stainless steel or similar, and have an automatic cleaning system.

In waste management equipment wash rooms, bulkheads, deckheads, and decks need to be constructed to meet the same standards described for the spaces for the storage, preparation and service of food. A bulkhead-mounted pressure washing system can be provided with a deck sink and drain. An enclosed automatic equipment washing machine or room may be used in place of the pressure washing system and deck sink. Adequate ventilation is required for extraction of steam and heat.

For garbage holding facilities, it is advisable to ensure that the storage room is well-ventilated, and that temperature and humidity are controlled. A sealed, refrigerated space can be used for storing wet garbage. The space needs to meet the same criteria utilized for cold storage facilities for food.

A garbage- and refuse-storage or holding room can be constructed of adequate size to hold unprocessed waste for the longest expected period when off-loading of waste is not possible. The refuse-storage room can be separated from all food preparation and storage areas.

The sorting tables in garbage processing areas can be constructed from stainless steel or similar and have coved corners and rounded edges. Deck coaming, if provided, needs to be adequate, such as at least 8 cm (3 in) and coved. If the tables have drains, it is best to direct the table drains to a deck drain and install a strainer in the deck drain.

A storage locker can be provided for cleaning materials to keep them away from foods.

Adequate lighting, such as at least 220 lux (20 foot candles), is required at work surface levels and light fixtures need to be recessed or fitted with stainless steel or similar guards to prevent breakage.

In all the garbage holding and processing facilities there needs to be easily accessible handwashing stations with potable hot and cold water, hose connections, and sufficient number of deck drains to prevent any pooling of water.

Water supply for food refuse grinders

Approved back flow preventers (vacuum breakers) or acceptable air gaps can be installed in the water supply lines to the grinders (see section 10.2.1).

Dry refuse

To facilitate storage, tops and bottoms can be removed from all empty metal containers, or containers with metal ends, and the remaining parts flattened. Containers of paper, wood, plastic, and similar materials can also be flattened for convenient space saving storage.

Dry refuse can be stored in tightly covered bins, or in closed compartments, protected against weather, wash, and the entry of rodents and vermin. The containers can be thoroughly cleaned after emptying and treated with insecticides or pesticides, if necessary, to discourage harbourage of rodents and vermin.

10.6 Legionnaires' disease

The construction issues associated with *Legionella* control were considered in the above sections on water safety (section 10.2) and recreational water environments (section 10.4).

It is important in designing the ship to minimise the extent of points where water could collect and become warm and stagnant. For example, temperature control valves that prevent scalding can be fit as close to the point of use of water as possible to minimise the formation of pockets of warm water. The extent of distribution system dead ends can be minimised. Rooms housing recreational water environments can be well ventilated to avoid an accumulation of *Legionella* in the indoor air.

10.7 Disease vector control

10.7.1 Insects

Sleeping quarters, mess rooms and dining rooms, indoor recreational areas, as well as all food spaces, can be effectively screened when vessels are in transit in areas where flies and mosquitoes are prevalent. Screening of sufficient hole tightness, such as no more than 1.6 mm spacing, is recommended and can screen all outside openings. Screen doors can open outwards and be self-closing, and the screening can be protected by heavy wire netting or other means to protect it from damage, and this may well include the use of metal kick plates.

10.7.2 Rodents

Rats and mice gain access to ships by various means including gaining access directly by hawsers and gang plants. Others may be concealed in cargo, ship's stores and other materials taken onto the ship. However, the prevention of rat harbourage through appropriate construction and rat-proofing will ensure almost complete control of rodents aboard the ships.

Some ships may be difficult to rat-proof without major alterations. However, there are many rat-proofing measures that can be readily undertaken. These will materially reduce rat harbourage and will keep rat populations to a minimum after the vessel has been deratted, provided that appropriate operational control measures aboard ship are regularly followed.

Concealed spaces and structural pockets, openings that are too large, such as greater than 1.25 cm, leading to voids and food spaces, gaps around penetrating fixtures (e.g. pipes or ducts passing through bulkheads or decks) regardless of location, need to be obstructed with rat-proofing materials, and the insulation layer around pipes, where over a certain thickness, such as

1.25 cm thick, needs to be protected against rat-gnawing.

The purpose of rat-proofing is to avoid small enclosed spaces that preferred rat habitat and at the same time entry ways that are large enough, or can be made large enough through damage or gnawing, for rat entry.

Materials used for rat proofing

Rat-proofing materials can be thick enough to resist tearing by rats and able to withstand any blows to which they may be subjected within the areas of use. Such materials include steel plate, sheet iron or steel, sheet aluminium or metal alloy of suitable hardness and strength, perforated sheet metal, expanded metal, flattened expanded metal, wire mesh and hardware cloth.

Expanded metal, flattened expanded metal, perforated sheet iron, wire mesh or hardware cloth used for rat proofing would need to meet the maximum opening requirements.

Metal wire or sheet metal gauges must meet adequate strength and corrosion resistant qualitys. For example, aluminium can have a thickness by the Brown & Sharp gauge greater than the thickness specified by the US Standard for sheet iron because aluminium is not as strong. For example, 16-gauge aluminium (Brown & Sharpe) might replace 18-gauge sheet iron (US Standard). For grades of wire and hardware cloth, Washburn & Moen gauges are also used.

Acceptable non-rat-proof materials

Certain non-rat-proof materials are satisfactory in rat-proof areas provided that the boundaries and various gnawing edges are flashed. Wood and asbestos composition materials are acceptable under conditions such as:

- Wood can be dry or seasoned, and free of warps, splits and knots. Plywood can be resin-bonded and water proof.
- Inorganic composition sheets and panels can be relatively strong and hard, and with surfaces that are smooth and resistant to the gnawing of rats. A list of acceptable non-rat-proof materials may be obtained from national health administrations. If a new material is intended for use, the national health administration can be consulted in order to initiate approval procedures.
- Certain composition sheets and panels that do not meet the requirements in the bullet point above may be made acceptable by laminating with metal or facing on one side, for example, a 24-gauge sheet steel or 22-gauge aluminium. Another method is to face both sides of such composition sheets or panels with, for example, 24-gauge sheet steel, 22-gauge aluminium or a hard-surfaced composition material. All materials in this category are likely to be subject to health administration approval for inclusion in an acceptable non-rat-proof materials list.

Cements, putties, plastic sealing compounds, lead and other soft materials, or materials subject to breaking loose, are not advised in place of rat-proofing materials to close small openings. Firm, hard-setting materials used to close openings around cables within ferrules might need to be approved by the ship inspection officer. Fibre boards and plaster boards are generally not acceptable non-rat-proof materials. For approval, consult the relevant health administration.

Surfaces not requiring rat-proofing

Non-rat-proof sheathing need not be rat-proofed when placed flush against, or not more than a suitable distance, such as 2 cm (0.75 in), from, steel plate, or when placed flush against rat-proofing material over insulation. Overlapping joints or minimum thicknesses are not necessary for sheathing so placed.

Wooden screen bulkheads need not be rat-proofed when placed flush against, or not more than a suitable distance, such as 2 cm (0.75 in) from, steel plate or other rat-proofing material. Rat-proofing is also unnecessary when the screen bulkhead is constructed on vertical bearers of suitable thickness, such as at least 10 cm (4 in) thick, terminates far enough above, such as at least 15 cm (6 in) above, the deck or other horizontal ledge, and extends far enough from, such as to within 2 cm (0.75 in), the deck head, but not into the bosoms of the beam, girders or brackets, the screen need not fit flush against the outside edge of the beam, girder or bracket, but the clearance should not exceed a suitable distance, such as 1.25 cm (0.5 in). When the screen bulkhead is so constructed, overlapping joints are not necessary. If additional protection is required for the bulkhead, tank-side or rat-proofing over insulation behind the 15 cm (6 in) opening at the bottom, a strip of sufficient width, such as 3 mm (0.125 in), plate or heavier sheet iron can be placed over this surface. The sheet iron should be wide enough, such as at least 5 cm (2 in), to be wider than the opening at the bottom. From a rat-proofing standpoint, this type of screen bulkhead is preferable to metal-sheathed or flashed types. Single subdivisional bulkheads in rat-proof areas need not be rat-proofed.

General criteria for rat-proofing

The following areas can be rat-proof as defined in the glossary: galleys, pantries, enclosed bars, refrigerated spaces, cargo holds, refrigerated cargo holds, tonnage openings, storage spaces (including deck lockers, slop lockers, electric panel lockers, etc.), forepeaks, afterpeaks, chain lockers, CO_2 rooms, engine rooms, boiler rooms, also the perimeters of fan rooms, auxiliary machinery spaces, and shaftways (including lift shafts), and other similar areas. Service installations, equipment, furniture and fixtures within the above rat-proof areas can be installed in such a manner as to eliminate rat harbourages. They would preferably be easily inspectable. Otherwise, they would need to be made rat-proof.

The following areas can be rat-tight as defined in the glossary: quarters, dining rooms and mess rooms, other public spaces such as lounges, salons, theatres and similar areas, also the fan-room casings, gyro room, radio room, chart room, wheelhouse, plenum chambers and other similar areas. Service installations, equipment, furniture and fixtures within the above rat-tight areas can be installed in such a manner as to eliminate rat harbourages. They would preferably be easily inspectable or made rat-tight.

The following are examples of methods for making an area rat-proof:

- Penetrations of rat-proofing material. All such penetrations would be kept within a suitable width, such as 1.25 cm (0.5 in), of the penetrating fixture or closed to within a suitable width, such as 1.25 cm (0.5 in), with rat-proofing materials. Penetrations of pipes, cables, ducts and other fixtures subject to movement can be closed to within a suitable width, such as 6 mm (0.25 in) on all sides so that the maximum opening will still be no greater than a suitable width, such as 1.25 cm (0.5 in).

- Penetrations of acceptable non-rat-proof material in rat-proof areas. Gnawing edges can be flashed. The perimeter of an opening in these materials caused by the penetration of structural members and service lines can be rat-proofed by placing a sheet iron collar to within a suitable distance, such as 6 mm (0.5 in), of the penetrating fixture and fastening it to the penetrated surface. Although 22-gauge sheet metal is sufficient for rat-proofing purposes, heavier-gauge metal is recommended for those areas that may be subject to damage. In cases where 22-gauge metal is specified, the minimum overlap of each gnawing edge by the metal collar should be sufficient, such as 2.5 cm (1 in). Plastic pipe should be collared snugly and provided with a sleeve of rat-proof material extending sufficiently, such as 30 cm (12 in), from the bulkhead on each side.

- Joints and perimeters of acceptable non-rat-proof material in rat-proof areas. Gnawing edges can be flashed. The flashing material can be on one side of the non-rat-proof material, either visible or concealed. In cases where 22-gauge sheet metal is specified, the minimum overlap of each gnawing edge should be sufficient, such as 2.5 cm (1 in). This criterion applies to all joints and perimeters including vertical and horizontal seams, at corners, decks and deck heads. Flashing need not be placed over tightly fitted tongue-and-groove, shiplap, or similar overlapping joints.

- Acceptable non-rat-proof materials that are metal-faced or laminated are rat-proof at gnawing edges, and no further protection of joints and perimeters is necessary.

- Penetrations in rat-tight areas. Such penetrations need not be protected at the gnawing edges if they fit snugly. Openings that are not snug should be collared, for example with 22-gauge sheet metal securely fastened. In all cases, no openings greater than a suitable distance, such as 1.25 cm (0.5 in), should be permitted.

- Joints and perimeters in rat-tight areas. Joints and perimeters in such areas, including vertical and horizontal seams at corners, decks and deck heads, can fit tightly in conformity with good shipyard practice.

- Double bulkheads. Double bulkheads dividing two rat-proof areas can both be rat-proofed if the void between them is too great, such as greater than 2 cm (0.75 in). If the void is small enough, such as less than 2 cm (0.75 in), only one of the bulkheads requires rat-proofing.

- Double bulkheads dividing a rat-proof from a rat-tight area may be made rat-proof on either side if the void is less than a suitable width, such as 2 cm (0.75 in), and can be made rat-proof on the rat-proof side if the void between them is too great, such as greater than 2 cm (0.75 in).

- Double bulkheads dividing two rat-tight areas need not be made rat-proof, regardless of the void between them.

- Flooring: deck coverings, portable flooring and other standing surfaces. Permanent flooring in rat-proof areas can be protected to prevent rat harbourages. Whenever possible, such flooring can be so constructed as to eliminate void spaces greater than a certain width, such as 2 cm (0.75 in) between the flooring and the steel deck. Allowance can be made for the welding beads of the joints and for the difference in the elevation of lap-welded plates. In some cases, the adjustment can best be made by the use of suitably thick, such as1.25 cm (0.5 in), hardwood or 1 cm (0.4 in) metal bearers. Permanent flooring with a void beneath greater than a certain size, such as 2 cm (0.75 in), must be made rat-proof by flashing all gnawing edges and collaring all penetrations, leaving no openings greater than a suitable width, such as 1.25 cm (0.5 in). Flooring of concrete or of hard-composition material over voids or insulation thicker than a certain thickness, such as 2 cm (0.75 in), can be kept not less than a certain thickness, such as 5 cm (2 in) thick, and can be reinforced with large-mesh material. When a flooring consists of a layer of concrete and a layer of composition material, the concrete can be made sufficiently thick, such as at least 3.8 cm (1.5 in) thick, and one of the layers can be reinforced. In all cases, the cove at the boundaries and the curb or sheathing above the flooring and grating needs to be rat-proofed. When the bulkhead sheathing is of acceptable non-rat-proof material and there are openings greater than a certain size, such as 1.25 cm (0.5 in), between the bottom of the bulkhead sheathing and the steel deck, the cove of the flooring can be rat-proofed with a suitable, such as 18-gauge, steel wire mesh, 18- to 20-gauge flattened expanded metal, or 18-gauge expanded metal will be acceptable, extending sufficiently, such as 2.5 cm (1 in), above the bottom of the gnawing edge of the bulkhead sheathing and far enough, such as 10 cm (4 in), into the composition flooring. If the bulkhead sheathing is of acceptable non-rat-proof material and there are no openings larger than an acceptable size, such as 1.25 cm (0.5 in), between the bottom of the bulkhead sheathing and the steel deck, rat-proofing at the cove of the flooring is not required. Portable flooring, whether solid or open-type, can be in sections of such size and weight as to be easily handled. When a hoist is not available, the portable sections should not exceed a suitable size, such as 3.3 m^2 (26 ft^2), in area nor weight, such as 54 kg (120 lb). When a hoist is available, each section should be less than a suitable size, such as 7.0 m^2 (75 ft^2) in area, and should be provided with a flush ring or other means for the attachment of a hoist cable.

Construction details

Hull and supports

Horizontal stiffeners, including structural members over doors and cargo ports, can be installed toe down wherever practicable, to eliminate the partially hidden area formed behind the flange when it is placed toe up. When deep recesses cannot be easily inspected, or when structural pockets are created by the intersection or close approach of several structural members, the space can be enclosed.

Lightening holes and void spaces

Lightening holes, when used as a means of opening spaces, can be large enough to make the surfaces inside easily visible and thus unattractive to rats as a nesting place. In no case would the cutting of lightening holes be recommended where the strength of structural members will be adversely affected.

Void or concealed spaces, such as coffer-dams, spaces around the chain lockers or tanks and between the breasthooks, and spaces opened by lightening holes, either can be made accessible, easy to inspect, and open to light, or would be adequately rat-proofed. Such spaces, when intended for the stowage of dunnage, gear, or miscellaneous material, would be enclosed and provided with hinged entrance doors or manhole covers, with means of securing them.

It is preferable that such doors and manhole covers would be hinged at the top and be self-closing. If they are made of mesh material, the cut edges can be substantially bound with steel bars or sheet metal crimped over the edges. Drain or ventilation holes or slots in solid sheet metal skirts around void spaces should be no greater an appropriate size, such as 1.25 cm (0.5 in).

Void spaces around, under and above tanks and other fixtures can be left open, if inspectable from at least two sides. This does not apply in food storage and food preparation areas, where all void spaces would be sealed.

Foundations for equipment inside vessel

Except in engine rooms, the bases or foundations of machinery and equipment, including water tanks, in both rat-proof and rat-tight areas can be designed and installed so as to eliminate any partially enclosed spaces. Open-type structural steel foundations are preferred. Where lightening holes are not sufficient to permit inspection and additional lightening holes cannot be cut, the existing openings can be closed to within a suitable size, such as 1.25 cm (0.5 in), with adequately strong, such as at least 22-gauge sheet metal, or sufficiently small, such as 1.25 cm (0.5 in), mesh material. In commissariat spaces, all foundations can be completely closed. Openings between the top of box foundations and the base of machinery exceeding a certain size, such as 1.25 cm (0.5 in), can be rat-proofed.

Steel tank-tops in lower hold

Where practicable, steel tank-tops would extend to the ship's side, to avoid the creation of an open bilge space and the need to install a bilge ceiling. Pipes at the ship's side can be protected by battens. Cover plates over open drain-wells can be perforated or slotted.

Wood pads in cargo holds

Wooden cargo pads in general cargo holds can be installed in direct contact with the tank-top or on suitably thick, such as 1 cm (0.4 in), flat-bar bearers. In no case would the space between the cargo pad and the tank-top be greater than a suitable width, such as 2 cm (0.75 in). When thicker bearers are placed under a cargo pad, the space in excess of a suitable size, such as 2 cm (0.75 in), should be filled, for example with asphalt or bituminous cement, or some other material that is impenetrable to rats. Cargo ramps can be constructed of steel plate; if wooden they should be completely covered with an appropriate protectant, such as 11-gauge sheet metal when the space beneath is greater than a certain size, such as 2 cm (0.75 in). Wooden cargo pads over cork insulation in refrigerated cargo holds can be made of tongue-and-groove or shiplap, sufficiently thick, such as at least 6.5 cm (2.6 in) thick, and bound with steel or similar protectant. It is desirable that adequately thick protectant, such as 18-gauge or heavier steel wire cloth, should be placed between the ceiling and the cork, but a ceiling with tightly fitted shiplap or caulked butt joints is acceptable.

Bilge ceilings

If possible, bilge ceilings can be eliminated, and open-type protection (such as battens) provided for frame brackets, pipe, and similar appurtenances. Permanent bilge ceilings, if required, can be constructed of steel plates or similar material wherever practicable. Drainage openings can be provided by using plate perforated with holes not exceeding a suitable diameter, such as 1.25 cm

(0.5 in).

When wood is used for bilge ceilings, it should be sufficiently thick, such as at least 6.5 cm (2.6 in) thick, and should be completely covered with sheet metal or similar protectant of sufficient thickness, such as 16 gauge. A ceiling that is composed of a series of portable panels can have each panel completely covered with sheet metal or similar protectant, of sufficient thickness, such as at least 16 gauge. With this type of construction, the sheet metal covering the fixed wooden ceiling, and that over the portable panel, can extend to the underside of the members, and be securely fastened so that the edges of the sheet metal will not be exposed.

Shaft-alley ceilings

The wooden pad that is placed over the steel plate forming the shaft-alley in cargo holds can be laid flush against the plate or not more than a suitable width, such as 2 cm (0.75 in), from any point on the plate. When the void space between the steel plate and the wood ceiling exceeds a suitable distance, such as 2 cm (0.75 in), the wood is to be completely covered with a suitable protectant, such as 16-gauge sheet metal.

Chain lockers

Chain lockers can be so designed as to prevent any rats from entering by way of the chain pipe. The bulkhead surrounding the locker can be of metal, and have no holes larger than a suitable width, such as 1.25 cm (0.5 in). A bulkhead dividing the locker in two need not be rat-proofed. Entrance doors into a chain locker, and lightening holes into the spaces on each side of the locker, can be of rat-proof construction. When the chain-storage space is not partitioned from the forepeak the entire space can be considered the chain locker, and any stowage lockers located in this space can be rat-proofed.

Doors

Doors of acceptable non-rat-proof material, if they lead into rat-proof areas, can be closely fitting and covered on the outside lower edge with a suitably wide strip, such as 15 cm (6 in), of sufficiently robust protectant, such as 22-gauge or heavier sheet metal.

Construction holes which may be left in the top and bottom edges of prefabricated metal doors need not be rat-proofed.

Slots in louvres and the space between the sills and the bottom of entrance doors and of doors within living quarters, dining rooms and other public spaces leading to passage ways, can be kept within a suitable width, such as 1.25 cm (0.5 in) or less. This limitation is not essential for entrance doors to toilets, bathrooms and wardrobes within these spaces.

Recesses for sliding doors can be rat-proofed, and, in the case of open-type sliding doors, wide enough to permit inspection and easy cleaning.

Window casings

Window casings in double walls or bulkheads can be of tight construction and preferably of metal. If they are not rat-proof, there can be no excessive large space, such as no space larger than 1.25 cm (0.5 in), between the window sash or glass and the edge of the opening, whether the window is open or closed. For a window which does not slide in a tight groove, this opening can be limited to a suitable width, such as 6 mm (0.25 in), on each side of the sash or glass, to avoid an opening exceeding an unsuitable size, such as 1.25 cm (0.5 in) when the window shifts to the side. This is not necessary if the window well is rat-proof. A removable inspection panel can provided for a window sash that does not drop to within a suitable distance, such as 1.25 cm (0.5 in), of the well. Windows that slide horizontally into a double well or bulkhead can pass into a pocket constructed in the same manner as the window well recommended above.

Ballast

Permanent ballast can be so installed as to avoid the creation of a rat harbourage. Solid block, gravel, or sand ballast may be completely sheathed with a layer of reinforced concrete or cement mortar of sufficient thickness, such as at least 5 cm (2 in) thick, and then needs no further rat-proofing. Wooden sheathing for permanent gravel, sand, or block ballast should be suitably thick, such as at least 6.5 cm (2.6 in) thick. Sheathing composed of tongue-and-groove or shiplap planking need not be covered with metal but the outer gnawing edges can be flashed. Horizontal surfaces on which cargo is placed, particularly under cargo hatches, can be covered with a protectant such as steel plate. The lining of access manhole wells can be rat-proofed in the same manner, and the edges of the covers of these wells can be completely bound with a suitable protectant, such a 16-gauge or heavier sheet metal. Structural steel angles can be used at vulnerable corners in cargo holds.

Skylights

Skylights in areas for the handling, preparation, storage or service of food should be screened with suitably small and robust screening, such as 1.25 cm (0.5 in) mesh steel-wire cloth, with a gauge suited to the span, space, and exposure, such as no less than 18-gauge. Copper or other corrosion resistant insect screens, though necessary in these areas, are not necessarily rat-proof.

Manholes

Manhole protective covers or guards, can be made of a suitable material, such as steel plate, with no opening greater than a suitable size, such as 1.25 cm (0.5 in). If they are made of wood, and the void spaces created when the unit is in place are greater than a certain width, such as 2 cm (0.75 in), in any dimension, the entire inside can be lined with a suitable protectant, such as 22-gauge sheet metal. Flashing of the gnawing edges will be sufficient if tongue-and-groove or plywood is used.

Service facilities - protection from damage

General

To help avoid nesting and sheltering points and desirable habitat, service facilities such as pipes, cables and ducts can, whenever practicable, be protected with open, slot-type barriers, rather than with box or enclosed types.

Battens

Steel flat-bar, half-rounded-bar, channel or angel battens are preferred, but wooden battens are acceptable. Battens can be so installed as to form no troughs or partially hidden pockets over structural members, cables, or wire-way casings. Steel or wooden battens can be sufficiently far, such as at least 5 cm (2 in), apart and suitably far, such as at least 5 cm (2 in), from any adjoining pipe or bulkhead. The space between them can be sufficient to ensure visibility, but never less than the width of the batten, except in the case of vertical pipe battens.

There can be sufficient space, such as of at least 5 cm (2 in), between the batten bearer and the surface being protected. Battens can have a suitable minimum clearance, such as of 15 cm (6 in), from the deck, except that the cargo face, if vertical, may extend to the deck. Vertical, channel-iron pipe-guards and close spaced angle-iron pipe-guards which extend to the deck or tank top can have half-moon inspection holes at the bottom of the guard. Horizontal battens can have a suitable minimum clearance, such as of 15 cm (6 in), above the deck or tank top with which they are parallel.

Plate guards

Wide plate guards are generally undesirable, because they exclude light, interfere with inspection, hide rat runways, and create rat harbourage. When installed, they can be carefully located, and can be provided with sufficient lightening holes to overcome these objections.

Semicircular, channel-type and angle-type guards, when in a horizontal position, can be toed down and so placed as not to hide any surface that might serve as a rat runway. Channels and angles in a horizontal position might not be toed up, unless the ledge created by the lower flange is readily visible. Channels would not be used where they hide the upper surface of, or space between, horizontal pipes, cables and similar appurtenances.

Protective covers for heating pipes or coils, and for kickplates by doors, would not extend to the deck, nor horizontally beneath the pipe or coil. It is preferable that protective covers for pipes terminate sufficiently far, such as at least 15 cm (6 in), above the deck, and that they be open at both ends. If complete enclosure is necessary, there would not be any holes in the casing larger than a certain size, such as 1.25 cm (0.5 in).

Wire-way and cable guards

Wire-way and cable guards of the metal-bar type are preferable from a rat-proofing standpoint. They would be installed wherever the location of the cable or wire-way is such as not to create any rat harbourage and not to prevent the inspection of the top of the wire-way. In places where harbourage is created, the cable or wire-way can be enclosed in a rat-proof casing.

Bar-type guards can be constructed of bars that are not too wide, such as not over 5 cm (2 in) in width, so placed as to have sufficient clearance between the bars, such as 5 to 10 cm (2 to 4 in). In no case would the clearance between bars at the side be too small for access, such as less than 3.8 cm (1.5 in). The cables can be so placed that the top of each layer is opposite the top of a bar. The cables would be in groups, preferably not more than a suitable width, such as 20 cm (8 in) wide, with a suitably wide opening, such as of at least 5 cm (2 in), between groups. The slots thus created would be above each other where there are several layers of cables, and the bars that form the underside of the wire-way guard would not be below these slots.

Casing-type wire-way or cable guards would be of adequate strength and of material suitable to the space in which they are installed. Metal casings are preferred, but non-rat-proof materials are acceptable is passageways and similar spaces.

Wire-way casings would consist of portable sections. The weight and size of each section, and the method of attachment, would be such as to facilitate removal and replacement.

Casings would extend continuously through rat-proof boundaries or double bulkheads; otherwise, the openings in these bulkheads through which the cables pass would be rat-proofed.

Cable and wire-way casings and junction boxes would be placed far enough above, such as at least 15 cm (6 in) above, the deck flooring, or the space would be rat-proofed.

At the deck-head, wireway casings that are parallel to the beams would be placed as recommended for ventilating and heating ducts. Those casings that are below and at right angles to the deck-head beams should terminate at the lower surface of the deck-head beams, and should not extend into the space between the beams.

Cables should enter casings through nipples or stuffing tubes. Sheet-metal collars would be installed at such penetrations of expanded metal if there are openings greater than a certain size, such as 1.25 cm (0.5 in).

Service facilities - installation

General

Service lines can be installed in such a manner as to avoid creating rat harbourages and spaces that cannot be inspected and cleaned, insofar as this is possible.

Most service line installations can be left open. Where areas are created that cannot be inspected, the need for rat-proofing will have to be determined with due consideration of such factors as the amount of light above the service lines, the space existing between them, and whether or not any of the lines or adjacent fixtures are insulated.

When rat-proofing is necessary, service lines can be completely encased. When enclosures are necessary in passageways, the facilities can be placed high enough to permit easy inspection through removable panels.

All penetrations (by pipes, cables, wire-ways and ducts) of bulkheads, decks, deck-heads and partitions that form the boundaries of rat-proof spaces can be rat-proofed.

Pipes

All exposed pipes, except in propelling machinery and refrigerating machinery spaces, can be installed away from corners, stiffeners, bulkheads, bosoms of beams, brackets and similar fixtures. They should be sufficiently far apart to permit easy inspection. For example, at least 5 cm (2 in) can be left between pipes, and between a pipe and any surface parallel to it.

When it is necessary to place pipes in contact with one another in horizontal layers, the grouping can be limited so that, for example, they are less than about 20 cm (8 in) in width and there is a suitable width, such as 5 cm (2 in), between groups. When these provisions are impracticable, so that surfaces that cannot be inspected and rat harbourages are created, enclosure may be essential.

Horizontal pipes can be kept sufficiently far, such as at least 15 cm (6 in), from the deck or tank top, and a sufficient distance from bulkheads, sheathing and structure of deck.

In cargo holds, stowage places and other infrequently occupied rat-proofed areas, plastic pipe can be entirely protected with rat-proofed material.

Cables - electric, telegraphic and degaussing.

Cables in groups can be attached directly to bulkheads or deck-heads, or within a suitable distance, such as 1.25 cm (0.5 in), of them, wherever practicable. The grouping can be limited to a suitable amount, such as about 20 cm (8 in) in width, and there should be sufficient space, such as at least 5 cm (2 in), between groups. When cables are not encased, the backing plates to which the cables are attached can be laid out with not more than a suitable width, such as 20 cm (8 in) wide, with a suitable, such as 5 cm (2 in), space between neighbouring plates.

When an open, inspectable type of cable installation is impossible and rat harbourage is created, the cables can be enclosed.

Cables can pass through stuffing tubes, thimbles, or nipples wherever they penetrate bulkheads, deck-heads and partitions, or enter closed wire-way guards and pull-fuse or switch boxes. Direct penetrations of metal surfaces by individual cables can be rat-proofed.

When sheet iron collars are installed, they can be fit to within a suitable distances, such as 6 mm (0.25 in), of the outer surface of the individual cable or group of cables. When placed around a wire-way, the inner edge of the collar can be cut to conform to the outer surface of the wire-way. A strip of sheet lead can be placed around the cable or wire-way, as a safeguard against the insulation being cut by the collar. Placing the two halves of the collar tightly against the cables will prevent vibration and cutting.

A heavy flange on a stuffing box, a washer behind a nut, or the nut of a nipple, if covering the gnawing edge of a penetration of hard composition material by a suitable width, such as at least 6 mm (0.25 in), will provide satisfactory protection in place of a sheet-metal collar.

Systems for ventilation, air-cooling, air-conditioning and heating.

Mushroom and torpedo ventilators in the superstructure would be continuous if they pass through double bulkheads or deck-heads. Where necessary, the sleeve of the ventilator can be extended by the addition of sheet metal. Penetrations of non-rat-proof bulkheads, deck-heads, or sheathing can be collared.

Air ducts can be so constructed and located that rat harbourages will not be created. They can be continuous where they pass through double bulkheads and insulation. Non-rat-proof materials are suitable for certain spaces other than general cargo holds, provided that all gnawing edges are flashed. Air ducts that traverse the void space within double bulkheads or deck-heads would be rat-proof.

Rectangular air ducts can be installed either tightly against deck-heads and bulkheads or entirely away from them to permit inspection. If not flush with the deck-head plate, the duct can be sufficiently below the deck-head beams to permit inspection of the top, such as not less than 5 cm (2 in), when the casing runs parallel to the deck support. In some spaces, it may be necessary to place the ducts between beams, but not flush with the deck-head. With this arrangement, the space on the side should be sufficient, such as at least 25 cm (10 in) wide, and the space above the casing sufficient, such as at least 7.5 to 10 cm (3 to 4 in), in order to permit inspection.

The cutting of lightening holes in adjoining structural members to facilitate inspection can be avoided unless good visibility is obtained by this means. Lightening holes would not normally be cut where they will adversely affect the strength of a structural member.

Spaces that cannot be inspected because of the arrangement of ventilating or heating ducts can be completely enclosed with a protectant such as sheet metal, or the need for rat-proofing can be determined with due consideration of such factors as the amount of light above the service lines, the space existing between them, and whether or not any of the lines or adjacent fixtures are insulated. Expanded metal or wire cloth is suitable in place of sheet metal, except in cargo spaces.

Screening of vent openings

Intakes, exhaust and outlets can be protected by rat-proof screening, unless the opening is equipped with a louver in which the slot or hole is small enough, such as not greater than 1.25 cm (0.5 in). Insect screening is not satisfactory as rat-proofing as the strength is too low.

All gravity and forced-draft intake and exhaust openings can be rat-proofed. An individual gravity ventilator or forced-draft duct that passes directly into one compartment needs to be rat-proofed on the intake end but the outlet end need not be rat-proofed, unless a rat harbourage is created by a horizontal extension of the duct. Ducts extending from the weather deck directly to the cargo holds, engine room and boiler rooms, with no horizontal extensions, need not be rat-proofed at either end. The service outlet of a cold-air or hot-air system that serves more than one compartment can be rat-proofed. Ventilation-louver openings in living quarters, dining-rooms and other public spaces need not be rat-proofed, provided they are located in the deck-head near the centre of the space, and that there are no avenues of approach and little likelihood of one being provided.

Ventilating hoods and canopies can terminate flush with the deck-head, or can slope toward the open deck space. They can be screened as specified above. Pipes, cables, air ducts and similar features over tops of hoods can be grouped so as not to form spaces or pockets that will be inaccessible for inspection. If such spaces are formed, they can be completely closed with a suitable protectant, such as 18- or 22-gauge sheet metal, depending on the rat-proof areas involved.

Insulation

General

Rats have been observed to burrow through, and to harbour and raise young in, insulation commonly used on vessels. Insulation of sufficiently small thickness, such as 2.5 cm (1 in) or less in thickness, placed in contact with the surface being insulated without sheathing need not be rat-proofed. For insulation that is sheathed, rat-proofing will be required when the insulation is too thick, such as over 2 cm (0.75 in) thick.

All insulation thicker than a suitable thickness, such as 2.5 cm (1 in), would be rat-proofed, unless the insulation is within a rat-proofed void space or a rat-tight area. A combination of a void and an insulation thickness greater than a suitable thickness, such as 2.5 cm (1 in), would be rat-proofed.

Sheathing that covers insulation over a suitable thickness, such as 2 cm (0.75 in) thick, and is not of acceptable rat-proof material would be completely covered with a rat-proof material.

Expanded metal is satisfactory as sheathing of insulation in spaces other than galleys and pantries. The expanded metal would extend to within a suitable distance, such as 1.25 cm (0.5 in), of structural plates, or would join other rat-proofing material. When expanded metal is to be covered with a plaster coat, the plaster would not be applied until the expanded metal has been inspected.

When metal or wooden furniture is placed flush against insulation of too great a thickness, such as 1.25 cm (1 in) or more thick, a strip of a suitable protectant, such as 22-gauge sheet metal, would be placed on the part of the furniture that is adjacent to the insulation and would extend through the insulation to within a suitable distance, such as 1.25 cm (0.5 in), of the metal behind the insulation.

Deck

The deck-covering over insulation thicker than a suitable thickness, such as 2 cm (0.75 in), in rat-proof areas would be rat-proofed by completely covering the insulation with a suitable protectant, such as18-gauge expanded metal, 18- to 20-gauge flattened expanded metal or, in refrigerated spaces, 16-gauge steel-wire cloth. When mesh material is essential, it may be placed just above the insulation, or within or between layers of the covering material.

General cargo holds

Insulation in general cargo spaces can have a suitable protectant, such as 16-gauge sheet metal, placed directly on the insulation. At the deck-head, a suitable protectant, such as at least 18-gauge sheet metal, can be used. When special protection is necessary, a heavier-gauge material is recommended.

Refrigerated cargo holds

Insulation on exposed surfaces within refrigerated cargo spaces would be rat-proofed by complete coverage with a suitable protectant such as sheet metal or flashed sheathing.

Spaces for refrigerating machinery

Insulation on machinery, pipes, pipe manifolds, valve cabinets and similar appurtenances within refrigerating machinery spaces are exempted from rat-proofing, provided that the boundary bulkheads and deck-head, the sheathing over voids or their insulation, and the penetrations of bulkheads and the deck-head are rat-proofed and the door is conspicuously labelled, such as with the words “KEEP CLOSED”.

Casings for engines and machinery

Insulation on machinery, pipes, pipe manifolds, valve cabinets, and similar appurtenances in engine and machinery casings can be rat-proofed.

Galley and pantry

Insulation on the galley and pantry deck-heads and bulkheads can be sheathed with metal or some other hard, smooth surfaced material as protectant.

Sleeves

Sleeves can be installed round insulated pipes that pass through double bulkheads and deck-heads of refrigerated spaces. Service lines to refrigerated spaces can pass through the double bulkhead or deck-head within stuffing tubes; otherwise the service lines can be protected against the entrance of rats into the insulation around the pipe or the insulation within the double deck-head or bulkhead. The cork or other insulation around the part of a pipe or tube that is within a deck-head or between double bulkheads can be enclosed in a sufficiently robust sleeve, such as at least 22-gauge sheet metal. The sleeve would extend the full length of the pipe insulation, and would terminate at the outer surface of the bulkhead or deck-head in which the hole has been cut for the insertion of the pipe insulation.

In addition to the sleeve, sheet-iron collars can be placed around the penetrating pipe at the outer surface of bulkhead that are constructed of acceptable non-rat-proof material. When a bulkhead penetrated by a pipe insulation is of metal, a suitable removable collar can be installed. When an external bulkhead penetrated by a refrigerant pipe or tube is of metal, the annular space in the bulkhead around the pipe or tube should not be too wide, such as no wider than 6 mm (0.25in).

Pipes

Pipes and pipe fittings that carry brine or other refrigerants and are covered with hair felt or similar insulation need not be rat-proofed if the insulation in not more than a suitable thickness, such as 5 cm (2 in) thick. For insulation thicker than a suitable thickness, such as 5 cm (2 in), the need for rat-proofing must be judged on the basis of arrangement and location.

Other pipes insulated with hair felt or similar material thicker than a suitable thickness, such as 2.5 cm (1 in), can be rat-proofed, unless the pipe is within a rat-proof void space or a rat-tight area.

The need for rat-proofing of cork insulation (regardless of thickness) around pipes, including those carrying refrigerants, can be judged on the basis of arrangement and location.

When rat-proofing is necessary, it can consist of sheathing the pipe or pipes with a suitable protectant, such as at least 24-gauge sheet metal or 18- to 20-gauge hardware cloth. The wire cloth would be applied beneath the wrapping, and may be embedded in the insulation not too far, such as not more than 2.5 cm (1 in), from its outer surface. All penetrations of acceptable non-rat-proof material by insulated pipe can be collared

The issues associated with plastic pipe with insulation that is more than a certain thickness, such as 2.5 cm (1 in) or more thick, are the same as for metal piping.

Ducts for ventilating, air-conditioning and heating systems

Hair felt or similar insulation less than a certain thickness, such as 2.5 cm (1 in) thick, over ventilating, air-conditioning, and heating ducts need not be rat-proofed. For insulation that is too thick, such as over 2.5 cm (1 in) thick, rat-proofing will be necessary, except in rat-tight areas.

When a cork is used, the need for rat-proofing must be judged on the basis of arrangement and location.

Rat-proofing will not be necessary for vent ducts located within double bulkheads or deck-heads that are rat-proof, or in fan rooms that have rat-proof boundaries and whose doors are marked with words such as "KEEP CLOSED". Where this is not the case, rat-proofing can consist of complete coverage with a suitable protectant such as 24-gauge metal, 18- to 20-gauge steel-wire or hardware cloth, 20-gauge expanded metal, 20- to 22-gauge flattened expanded metal, or 1.8 kg/m^2 ($3.4\ lb/yd^2$) metal lath with an acceptable hard plaster coating. The rat-proofing material would be placed over the insulation and beneath any covering. In cargo spaces, the gauge of the rat-proofing material can be at least one even number lower due to the increased loads.

Machinery and equipment on deck

General

Machinery and equipment (and the foundations thereof) located on the weather deck would be so constructed or rat-proofed as not to provide any temporary hiding place or permanent harbourage for rats. Open-type construction is preferable. All spaces to which a rat might gain access would be sufficiently open to admit light and to facilitate inspection and cleaning. Where open construction is impracticable, closures would be effected with a suitable protectant, such as at least 16-gauge sheet metal, 13-gauge expanded metal, 13- to 15-gauge flattened expanded metal, or similar rat-proofing materials and would not contain any holes larger than a suitable size, such as 1.25 cm (0.5 in) in diameter.

When the space within the foundation or beneath a solid base or cover plate can be viewed from opposite sides, the height of the space can be made sufficient to permit easy inspection. When the space is less than a particular size, such as 15 cm (6in), creating a rat harbourage, the space would be closed.

Rope and cable reels

Rope and cable reels would be of suitable, such as metal, construction, and would be installed on open-type robust, such as metal, supports. The central core would be of solid or perforated metal. Hollow axles having a diameter of more than a suitable size, such as 2.5 cm (1 in), can be plugged, unless the area is inspectable.

Mooring fittings

Bitts, chocks, cleats and other mooring fittings can be either open for inspection or completely closed. Any rat harbourage within or adjoining such fittings can be rat-proofed with heavy rat-proofing material. Holes in castings larger than a suitable size, such as 1.25 cm (0.5 in), in diameter, such that are sometimes found in crucifix bitts, would be sealed with metal.

Space for stowage of facilities

Shelves

Shelves or platforms would be so installed as to avoid the creation of pockets or hidden places.

When such places are unavoidable, they would be enclosed with a protectant such as sheet iron of at least 22 gauge. Shelves and platforms used for the storage of foods would preferably be constructed of sheet metal or similar material.

Bins

Bins would be placed either flush against or well away from bulkheads and structural members. If they are not flush with the deck, the space underneath would be rat-proofed with a suitable protectant, such as at least 22-gauge sheet metal. All bins wuld have tight fitting covers, preferably of the self-closing type.

Spare-part boxes

Large spare parts, such as propellers, propeller blades and shaft sleeves, would be stowed in a rat-proof manner and would preferably not be encased. When they have to be encased and when the casing is of non-rat-proof material, rat-proofing will be necessary, unless the parts are stowed in a rat-proof compartment. Small spare-part boxes would be made of a suitable material, such as metal, unless they are to be stowed in a rat-proof compartment.

Lockers

All lockers would be installed in such a manner as not to form any rat harbourages at the deck or deck-head or with adjacent structures. If not placed flush with the deck, the locker would be elevated sufficiently, such as at least 15 cm (6 in), or the space closed with a suitable protectant, such as sheet metal of at least 22 gauge.

The boundaries of a locker adjacent to a void space created by a fixed false bottom would be made rat-proof or rat-tight according to the area.

In areas other than rat-proof or rat-tight areas, the lockers would typically be made of metal. They may be of wood or other acceptable non-rat-proof material provided they are properly lined or flashed with a suitable protectant, such as at least 22-gauge sheet metal. The edges of the lockers made of wire cloth or expanded metal would be bound with a suitable protectant, such as at least 22-gauge sheet metal.

Boxes

Weather deck boxes would preferably be made of metal. If of wood, they can be made rat-proof by lining the entire bottom and the lowest portion, such as the lowest 3.8 cm (1.5 in), of the sides with a suitable protectant, such as at least 22-gauge sheet metal or 18-gauge wire cloth. Other exposed edges of such boxes would be properly flashed. Storeroom boxes or boxes placed in other rat-proof areas would be made rat-tight.

Furniture and fixtures

General

Furniture, including wardrobes, would preferably be made of metal. Rat-proofing will not be required of wooden furniture that has no openings greater than a suitable size for rat entry, such as 1.25 cm (0.5 in), and that accords complete visibility of the interior of the base by such means as the removal of drawers or loose false bottoms. Wherever the interior of the base is not visible because of a complete or partial fixed bottom, or because a drawer cannot be removed, the gnawing edges can be protected.

Whenever possible, furniture and fixtures would be installed flush with the deck or elevated at sufficiently, such as at least 15 cm (6 in). Partially enclosed spaces around furniture should be closed with a suitable protectant, such as 22-gauge or heavier sheet metal, to within a suitable distance, such as 1.25 cm (0.5 in).

Galley fixtures

Fixtures in galleys should be so designed and located as to afford neither harbourage for rats nor places for the accumulation of food. All galley fixtures can be of metal, and all seams in them can be close-fitting, and preferably welded or soldered. Galley fixtures should be designed, constructed and installed to be satisfactory from a rat-proofing standpoint.

Electric refrigerators, drinking fountains and drinking-water coolers

The machinery compartment can be enclosed with a suitable protectant, such as 16-gauge wire cloth or 18-gauge expanded metal, or equipped with suitably small, such as 1.25 cm (0.5 in), louvers. Where holes are cut in the mesh for the passage of water pipes or electric cables, metal collars can be provided. Doors of machinery compartments can be tight-fitting on all sides.

10.8 Miscellaneous

10.8.1 Facilities and lockers for cleaning materials

Storage lockers are typically provided for cleaning material and equipment. If wet brooms, mops, or other wet equipment are to be stored in the cleaning lockers, the can be vented to avoid mould build up. Bulkhead-mounted racks can be used to hang wet brooms and mops, or sufficient space can be provided for hanging brackets within a cleaning locker. Bulkhead-mounted racks can be located outside food storage, preparation, or service areas. Stainless steel lockers can be used, with coved deck and wall junctures for storing buckets, detergents, sanitizers, and cloths.

The number of lockers and the location and size of lockers is determined by the needs of the vessel. Each area shall have convenient access to lockers containing cleaning materials. Accessible facilities for cleaning mops and buckets can be separated from food facilities. Cleaning lockers can be labelled with words such as “CLEANING MATERIALS ONLY”.

10.8.2 Ventilation systems

Air supply

Fan rooms can be made accessible for periodic inspections and air intake filter changing. Air intakes for fan rooms can be located so that any ventilation or processed exhaust air is not drawn back into the vessel.

All food preparation, warewashing, and toilet rooms would typically be designed to have a sufficient air supply. All cabin air vent diffusers can be designed to have easy removal and cleaning properties. A separate, independent air supply system can be supplied for the engine room and other mechanical compartments, such as fuel separation or purifying rooms, which are located in and around the engine room.

Air condition condensation collection pans can be designed to drain completely. Air condition condensate drainage from air chiller units can be through closed piping to prevent pooling of wastewater on the decks. Air handling unit condensate drain pans can be accessible for inspection, maintenance, and cleaning. All major air supply trunks can have access panels to allow for periodic inspection and cleaning.

Air exhaust

Air handling devices in the following areas can exhaust air through independent systems that are completely separated from systems using recirculated air:

- engine rooms and other mechanical spaces;
- hospitals, infirmaries, and any rooms used for patient care;
- indoor swimming pools, dome type swimming pools when closed, whirlpool spa facilities, and supporting mechanical rooms;
- galleys and other food preparation areas;
- cabin and public toilet rooms; and
- waste processing areas.

Negative air pressure can be maintained in the areas listed above. Sufficient exhaust system would typically be installed in all food preparation, warewashing and toilet rooms to keep them free of excessive heat, humidity, steam, condensation, vapours, obnoxious odours, and smoke. All major air exhaust trunks would typically have access panels to allow for periodic inspection and cleaning.

10.8.3 Child care facilities

Child care and child activity facilities can include:

- Handwashing facilities that are accessible without barriers such as doors to each child activity and child care area.
- Toilet facilities in child care and child activity centers including:
    - child size toilets;
    - handwashing facilities;
    - a covered waste receptacle; and
    - a sign advising users to wash their hands after using the toilet.

Child care facilities would typically provide diaper-changing stations and disposal facilities.

Each diaper changing station would include:

- a changing table designed for diaper changing that is impervious, nonabsorbent, nontoxic, smooth, durable, and cleanable;
- an airtight, soiled-diaper receptacle;
- an adjacent handwashing station; and
- a sign advising child-care facility staff to wash their hands after each diaper change.

Separate toilet and handwashing facilities are typically included for child care providers.

11 Owner/Operator

11.1 Introduction

The Owner/Operator of a ship provides a bridge between those that construct the ship and its crew. The overall responsibility of the owner/operator is to anticipate and proactively control sanitary risks to crew, passengers and communities that could be affected by ships arriving in ports.

There are established construction practices for controlling sanitary risks on ship (Chapter 10). It is the responsibility of the owner/operator to ensure that the ship is constructed in accordance with the requirements relating to ship sanitation, and/or that construction complies with the intent of those requirements through compliance with equivalent sanitary construction practices. The owner/operator can refuse to accept ships unless constructed by adequately experienced and qualified constructors with currency of compliance with any required certifications to ensure sanitary construction.

There are established operational frameworks for the control of sanitary risks on ships (Chapter 12). The owner/operator of the ship is responsible for requiring that the crew adopt good management practices in accordance with those established frameworks and/or equivalent sanitary control practices. The owner/operator of ships should ensure that crews are adequately resourced, experienced and trained to ensure sanitary operation.

The principles of proactive risk management should be applied in relation to all aspects of ship sanitation. In the body of this chapter these concepts will be illustrated primarily with reference to food and water safety. These same general concepts should be applied to all aspects of ship sanitation.

This chapter describes some of the relevant sanitary risk management frameworks required for ships and is structured into sections in accordance with the overall structure of this Guide.

11.2 Water Safety

Drinking-water safety needs to be managed within the context of a broader water safety framework as set out in the WHO Guidelines for Drinking-water Quality (GDWQ) (WHO 2004a). The water safety framework includes the setting of health-based targets, the development and implementation of a water safety plan (WHO 2004a; Davison et al 2005), and surveillance.

11.2.1 Multiple barriers

The supply of safe drinking water depends upon the use of either a protected high quality water source at the port or, if port water is non-potable, properly selected and operated series of treatments.

A long established principle in drinking water risk management is not to rely on a single barrier against pathogenic microorganisms, but to use a multiple barrier approach. No single treatment process can be expected to remove all the different types of pathogens that can be found in water. Multiple barriers will ensure additional safety in the case that a single treatment step is not working optimally. The number of treatment processes required is influenced by the quality of the source water. Information is required on the effectiveness of different treatment processes (as unit processes and in combination with other processes) in eliminating pathogens and on variation, including short-term, in effectiveness. The final quality of the water results from the sequential action of multiple barriers (control points). Multiple barriers reduce the risk of water becoming unsafe. Passengers and crew may be partly protected from the effects of poor performance of one barrier by the good performance of other barriers.

11.2.2 Health-based targets

Health-based targets are set by national and international agencies to provide criteria against which to assess the safety of a water supply system. The health-based targets can consist of one or a combination of three aspects:

- water quality targets: the definition of acceptable water quality in relation to the concentration of specified hazards (specific chemicals or microbes);
- performance targets: defined removal requirements based on an assumed source water quality; or
- treatment targets: direct specification of acceptable technologies for specific circumstances.

Further details of the health-based targets concept is given in the GDWQ. The GDWQ, IHR and this Guide provide a range of health-based recommendations relating to drinking water quality on ships

11.2.3 Water Safety Plan

The GDWQ are intended to cover a broad range of water supplies and are not specifically targeted towards ships. Therefore, in drawing from their guidance the specific context of the port and the ship needs to be taken into consideration. The overall approach promoted involving the development and implementation of a Water Safety Plan (WSP) (WHO 2004a; Davison et al 2005) is as relevant to ships and ports as to any other water supply situation. The WSP draws from the hazard analysis and critical control point (HACCP) approach applied as part of food safety programs (FSP) (described in Section 11.3).

A ship should have a declared WSP that is available for inspection and which includes a system description, a management plan, control measures and corrective actions. The WSP needs to cover all stages including:

- assessment of source water loaded onto the ship;
- the selection and operation of appropriate treatment processes; and
- the prevention of re-contamination during storage and distribution.

Although recognised as flawed, there has been an undue emphasis in assuring the safety of water on board ships through sampling of the end product. The detection of contaminants in both source water and water delivered to passengers and crew is often slow, complex and costly. Sampling can only verify that the water was safe when tested by which time it may have been consumed. It is not suitable for early warning or control purposes.

In contrast, the WSP approach is intended place the emphasis on preventing contaminated water reaching consumers by monitoring processes and practices. The objective is to detect possible contamination in time to enable correction to prevent suspect water being consumed. End-product testing then becomes a verification activity.

The WSP comprises three essential actions that are the responsibility of the ship operator and ship master. These are:

- system assessment and hazard analysis;
- management plan and control measures; and
- monitoring and corrective action system in accordance with that plan.

System assessment and hazard analysis

The purpose of the system assessment is to determine whether a system has control measures in place which would ensure that the health based targets are consistently met. System assessment involves understanding the characteristics of the drinking water system and source, what hazards may arise, how these create risks and the processes and practices that affect drinking water quality. System assessment covers both design and operation.

The ship operator should be aware of all the hazards (biological, chemical or physical) that may occur in port water or when transferring water from port to ship. Knowledge of these hazards may be obtained from various sources, for example, data on water quality from the port health authority or epidemiological data on waterborne disease in the region of concern.

Biological hazards include:

- Bacteria. *Salmonella typhi*, *Enterotoxigenic E coli*, *Shigella* and *Vibrio cholerae* have been associated with waterborne disease outbreaks on ships.
- Viruses commonly linked to waterborne disease include Hepatitis A and E and Norovirus. Those that infect humans and cause illness via the waterborne route originate primarily from human faeces, although there are some exceptions, such as Hepatitis E that can be derived from some animals.
- Protozoa of concern in water supplies are *Giardia* and *Cryptosporidium* which include zoonotic strains that originate from both human and mammalian faeces.

Chemical hazards can be considered as any chemical agent that may compromise water safety or suitability. Examples include pesticides, disinfection by products or organic toxicants.

Physical hazards may affect water safety by posing a direct risk to health (e.g. through choking), through reducing the effectiveness of treatment and in particular residual disinfectants.

Hazards may arise from contaminated source water, hoses, hydrants, cross connections and backflow and control measure need to be put in place to protect from such occurrences.

Management Plan and Control measures

Control measures are actions, activities and processes applied to prevent or minimize hazards from occurring or to reduce their levels. Control measures are those steps which directly affect water quality and which collectively ensure that water consistently meets health based targets.

It is useful to consider the causes of outbreaks when identifying control measures. For example, inadequate water treatment, improper loading of potable water, defective storage tanks, backflow of contaminated water due to defective backflow preventers, insufficient residual disinfection and poor supervision and training of crew members have all been identified as contributory factors (WHO 2001). This emphasizes the need for hygienic handling of water along the water supply chain from shore to ship and proper inspection and maintenance on board the ship to ensure water quality does not deteriorate.

After the hazard analysis is completed, the ship operator must consider what control measures, if any, exist which can be applied for the control of each hazard or hazardous event. Control measures are actions, activities and processes applied to prevent or minimize hazards from occurring or reduce them. More than one measure may be required to control a specific hazard and more than one hazard may be controlled by a specified measure.

The ship's operator must seek assurance as to the quality and nature of the source water before loading. Major lines (cruise, ferry) may choose to directly engage with port and local authorities to investigate levels of safety. If water is suspected of coming from an unsafe source, testing for contamination may be necessary. Additional treatment e.g. superchlorination or filtration, may be necessary. Terminal disinfection is a treatment step and, where a residual disinfectant is used, a final safeguard. Pathogens such as viruses and protozoa have a higher resistance to chemical disinfection than bacteria. Filtration is an important control measure and it may partially control more than one hazard.

Hoses should be handled with care to prevent contamination by dragging ends on the ground, pier, or deck surfaces, or by dropping the hose into the harbour. They must not be submerged in harbour water and should be stored in hose lockers. Hoses should be stowed with the ends capped. If a hose has become contaminated it should be thoroughly flushed and disinfected. Potable water hoses should be flushed before being used and should be drained after each use.

Hydrants should be checked routinely and be free from contamination. Non-potable water, if used on the ship, should be loaded through a completely different piping system using fittings incompatible for potable water. Hoses and air relief vents on ships should be visually checked to ensure potable and non-potable water are kept separate. All backflow preventers on ships and at port should be routinely checked and maintained

It is important that crew, including galley maintenance personnel, are trained in proper water handling procedures for loading and disinfecting water. Particular attention should be paid to flushing the hoses, disinfecting the loading points and keeping the hoses clean and capped. Hoses should be examined routinely and removed from use when cracks develop in the lining or leaks occur.

Monitoring and corrective action

Monitoring needs to take place in such a way that the possibility of contamination can be detected early enough that a corrective action can be completed to prevent contaminated water reaching passengers and crew.

Importantly, even very brief exposure to unsafe water can lead to an outbreak. As a result, faecal indicators such as *E. coli* are valuable for ongoing verification or for batch testing of water that is on hold and can be rejected if contaminated, but are of limited use for operational monitoring of water being supplied on ship.

Monitoring of barriers to contamination, such as backflow prevention devices and treatment systems, is important and can involve monitoring and measuring process performance indicators rather than the presence of hazards *per se*. Corrective actions involve repairing any defect and may require re-treating or discarding water that might be contaminated to ensure unsafe water is not supplied.

Periodic sanitary surveys of the storage and distribution system are an important part of any WSP. These are inexpensive to carry out and can complement routine water quality measurements.

Monitoring needs to be specific in terms of what, how, when and who. The focus for the control of process operation should be on simple measurements which can be done online and in field. In most cases, routine monitoring will be based on simple surrogate observations or tests, such as turbidity or structural integrity, rather than complex microbial or chemical tests. Infrastructure should be monitored e.g. checks for filter cracks pipe leaks, defective backflow preventers or cross connections. The disinfection process can be monitored on line by measurements of residual disinfectant, turbidity, pH and temperature; a direct feedback system can be included. As such tests can be carried out rapidly they are often preferred to microbiological testing. It is essential that all monitoring equipment be calibrated for accuracy.

It is important to check turbidity levels of source water as high levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria, and give rise to a significant chlorine demand.

Specific corrective actions must be developed for each control measure in the WSP in order to deal with deviations when they occur. The actions must ensure that the control measure has been brought under control and may include repair of defective filters, regular backwashing and cleaning of filters, repair or replacement of hoses or modification of target dose of disinfectant.

The ability to change temporarily to alternative water sources is one of the most useful corrective actions available but is not always possible. Backup disinfection plants may be necessary.

Documentation

A documented management plan needs to include the standard operational procedures to be adhered to that ensure the ongoing safe operation of the water supply system of the ship. Documentation and record keeping should be appropriate to the nature and size of the ship. Its purpose is to provide an evidence trail to support audit as well as to provide records to enable trends and system norms to be determined. Records should be archived and kept in accordance with the records management recommendations in prevailing standards and guidance. The actual duration of retrievable archiving required varies depending on the nature of the records and the jurisdiction.

11.2.4 Surveillance

Public health agencies need to undertake surveillance of water quality at ports and being carried on ships. Surveillance involves gathering objective evidence to verify that the WSP is effective at protecting water quality. There are two forms of surveillance: water quality monitoring and auditing.

The primary indicator of faecal contamination that is used in water quality monitoring surveillance is *E. coli* (or thermotolerant (faecal) coliforms). Regular water quality monitoring can be used to help build up evidence to show that water being supplied at port and aboard ship is not contaminated with fresh faecal material and other chemical and microbial hazards. The GDWQ provide explicit guidance on surveillance monitoring.

One limitation with water quality monitoring is that by the time contamination is detected it's likely that some of the contaminated water has been consumed. Therefore, surveillance should also extend to auditing whereby the processes in place to protect water quality are checked aboard ship and at port by an appropriately experienced auditor.

11.3 Food safety

11.3.1 Food Safety Framework

Food safety should be maintained within the context of a systematic food safety plan or program (FSP) based on the Hazard Analysis Critical Control Point System (HACCP) system. HACCP has been described in detail by FAO/WHO (CAC 1997a, b; 1999; 2003; ISO 22000:2005) and NACMCF (1997). This is analogous to the water safety plan discussed in Chapter 2. Such a system should be used as a tool to help determine critical control points specific to a particular menu i.e. the stages in the preparation and cooking of food which must be controlled to ensure the safety of the food. Once identified, a monitoring system can be set up for each critical control point to ensure that correct procedures are maintained and action taken if control point criteria are not achieved. The chief advantage of HACCP when properly applied is that it is proactive - it aims to prevent problems from occurring. In summary, this involves:

- identifying any steps in the food operation which are critical to food safety;
- implementing effective control procedures at those steps;
- monitoring control procedures to ensure their continuing effectiveness; and
- reviewing control procedures periodically and when ever operations change.

Food poisoning on board vessels can be reduced by control and careful selection of suppliers of safe food, training of food handlers, optimum construction of galleys and strict personal hygiene. Control measures for biological hazards include:

- Temperature/time control (proper control of refrigeration and storage time, proper thawing, cooking and cooling of food). Passenger ship operators should consider alternatives to packed lunches or eliminate potentially hazardous foods from their menus for packed lunches.
- Source control, i.e. control of the presence and level of microorganisms by obtaining

ingredients from suppliers who can demonstrate adequate controls over the ingredients and suitable transport to the vessel.

- Cross-contamination control, both direct (e.g. resulting from direct contact between raw to cooked food) and indirect (e.g. resulting from the use of the same utensils to contact both raw and cooked food).

- Proper cleaning and sanitizing which can eliminate or reduce the levels of microbiological contamination. Galleys should be designed so that the risk of cross contamination is reduced. Specific guidelines for sanitary conveniences and hand washing facilities for the shipping industry should be considered by those designing and maintaining ships. Seawater should not be used in or near food or food preparation areas.

- Personal and hygienic practices. It is recommended that ships have policies for ensuring infected people or chronic carriers do not perform any task connected with food handling. Food handlers with cuts, sores or abrasions on their hands should not handle food unless such sores are treated and covered. Staff should not be penalized for reporting illness. Preventing outbreaks attributed to infected food handlers requires the cooperation of employers, since many food handlers may conceal infection to avoid pay loss or penalty.

- It is important that First Aid boxes are readily available for use in food handling areas and that someone is appointed to take charge of first aid arrangements. It might be necessary for someone to be trained in aspects of first aid. There are no specific requirements covering the contents of a First Aid Box, but minimum contents might reasonably be a plastic-coated leaflet giving general guidance on first aid, individually wrapped sterile adhesive high-visibility dressings of assorted sizes, sterile eye pads, individually wrapped triangular bandages, safety pins, medium-sized (approximately 12 cm x 12 cm) individually wrapped sterile unmedicated wound dressings and one pair of disposable gloves.

11.3.2 Application of FSPs on ship

A FSP would generally be based around the HACCP steps and principles and the prerequisite supporting programs. The FSP is intended to provide a systematic approach to identifying specific hazards and measures for their control to ensure the safety of food. The FSP should be used as a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end product testing. The FSP should be capable of accommodating change, such as changes to the vessel menus, layout and equipment, advances in equipment design, processing procedures or technological developments. The FSP implementation should be guided by scientific evidence of risks to human health. As well as enhancing food safety, implementation of a FSP can provide other significant benefits including providing a framework to support inspection and certification by regulatory authorities and registrars. The successful implementation of a FSP requires the full commitment and involvement of both management and the work force.

Prerequisite supporting programs

The prerequisite supporting programs of a FSP include good construction, hygiene, training and raw material ingredient quality assurance. In addition, the ship should be operating according to any appropriate food safety legislation.

The core HACCP steps and principles will now be described very briefly as they relate to ships. It is important when applying HACCP to be flexible where appropriate, given the context of the application taking into account the nature and size of the operation.

Preliminary Steps

- Step 1. Assemble HACCP team. The food operation should assure that the appropriate knowledge and expertise is available for the development of an effective HACCP plan. The scope of the HACCP plan should be identified.
- Step 2. Describe the products. Full description should be given including storage conditions.
- Step 3. Identify intended use. Vulnerable groups of the population e.g. elderly may have to be considered.
- Step 4. Construct flow diagram. The flow diagram should cover all steps in the operation
- Step 5. Onsite confirmation of flow diagram. The HACCP team should confirm the processing operation against the flow diagram during all stages of operation and amend the flow diagram where appropriate.

HACCP Principles

- Principle 1. Hazard analysis. The team should list all potential hazards associated with each step, conduct a hazard analysis and consider any measures to control identified hazards. The team should list all hazards that may be reasonably expected to occur at each step. This includes identifying which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the preparation of safe food. The HACCP team must then consider whether control measures, if any exist, which can be applied to each hazard. More than one control measure may be required to control a specific hazard(s) and more than one hazard may be controlled by a specified control measure. In conducting the hazard analysis, wherever possible, the following should be included:
    - the likely occurrence of hazards and severity of their adverse health effects;
    - the qualitative and/or quantitative evaluation of the presence of hazards;
    - survival or multiplication of microorganisms of concern;
    - production or persistence in foods of toxins, chemicals or physical agents; and
    - conditions leading to the above.
- Principle 2. Determine Critical Control Points (CCP). There may be more than one CCP at which control is applied to address the same hazard. The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree, which indicates a logic reasoning approach.

- Principle 3. Establish critical limits for each CCP. Critical limits must be specified and technically validated for each CCP. Criteria often used include temperature, time, available chlorine and sensory parameters such as visual appearance and texture.

- Principle 4. Establish a monitoring system for each CCP. Monitoring is the scheduled measurement or observation of a CCP relative to its critical limits. The monitoring procedures must be able to detect loss of control at the CCP. Further, monitoring should ideally provide this information in time to make adjustments to ensure control of the process to prevent violating the critical limits. Where possible, process adjustments should be made when monitoring results indicate a trend towards loss of control at a CCP. If monitoring is not continuous, then the amount or frequency of monitoring must be sufficient to guarantee the CCP is in control.

- Principle 5. Establish corrective actions. Corrective actions must be developed for each CCP in the HACCP system in order to deal with deviations when they occur. The actions must ensure that the CCP has been brought under control.

- Principle 6. Establish verification procedures. Verification and auditing methods, procedures and tests, including random sampling and analysis, can be used to determine if the HACCP system is working correctly. The frequency of verification should be sufficient to confirm that the HACCP system is working effectively.

- Principle 7. Establish documentation and record keeping. Efficient and accurate record keeping is essential to the application of a HACCP system. Documentation and record keeping should be appropriate to the nature and size of the ship.

Training programmes should be routinely reviewed and updated where necessary. Systems should be in place to ensure that food handlers remain aware of all procedures to maintain the safety and suitability of food.

11.4 Legionnaires' disease

A WHO text (WHO 2006), currently in preparation, provides a framework for the risk management of Legionnaires' disease. The framework is similar to that used for the control of risks to water safety, as described in Section 11.2.

A responsibility borne by the owner/operator of the ship but not always directly performed by its crew under routine conditions, it testing. Testing for *Legionella* bacteria serves as a form of verification that the controls are working and should be undertaken periodically, e.g. monthly, quarterly or annually, depending on the type of ship environment. This testing should not replace, or pre-empt the emphasis on control strategies. Furthermore, the tests are relatively specialised and need to be undertaken by properly equipped laboratories using experienced staff and, therefore, are not generally performed by crews or during voyages. Verification sampling should focus on system extremities and high risk sites.

As for food and water safety, additional verification activities include independent auditing of operating procedures, training records and certification.

12 Master/Crew

12.1 Introduction

The Master/Crew of a ship provide the hands on operation of the ship's systems and processes and need to ensure sanitary operations to protect themselves, any passengers and communities that could be affected by ships arriving in ports. This chapter describes the sanitary operational control measures and practices required for ships and is structured into sections in accordance with the overall structure of this Guide.

12.2 Water safety

Water safety should be managed within the context of a Water Safety Plan (WSP) (WHO 2004a; Davison et al 2005) that covers both construction and operation of a ship and encompasses all process steps from source to consumer use. Familiarity and formal training in WSPs is an essential prerequisite to managing water safety aboard ship. Therefore, the generic aspects of WSPs are not described in this Chapter although they are described in Section 11.2.3).

12.2.1 Water production on ships

Production methods

Demineralised water

WHO guidance on desalination is in preparation. This is because if water is sourced by desalination of seawater, there may be health implications associated with long-term consumption.

A complete desalination process demineralizes the seawater. This makes it corrosive, shortening the life of containers and conduits and may have health impacts associated with insufficient minerals in the diet. Therefore, water produced by desalination is termed "aggressive". Special consideration needs to 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 stabilised by adding chemicals such as calcium carbonate with carbon dioxide as stabilizers. 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 would typically be subject to normal procedures for certification and quality assurance.

Reverse osmosis

The reverse osmosis process includes pretreatment, trans-membrane transport whereby water is transported across the membrane under pressure and salts are excluded, and often post treatment prior to distribution. Suspended solids are removed by filtration, pH adjustments protect the membrane and control the precipitation of salts.

Partial desalination or breaches in membranes may have potential health implications due to trace elements and organic compounds, including oil and refined petroleum products, that might be introduced because of pollution of seawater. In addition, seawater sources may contain hazards not encountered in freshwater systems. These include diverse harmful algal events of micro and macro algae and of cyanobacterial, 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.

Distillation

Distillation processes use heat and pressure changes to vaporize seawater, thus liberating it of its dissolved and suspended solids. Modern distillation plants primarily use multistage flash evaporators. In these systems, feed water is heated and then sent into a series of chambers or stages, each maintained at a lower internal pressure than the previous one. Because the boiling point of water decreases as pressure decreases, evaporation is achieved in each chamber without more heat being added.

A distilling plant that supplies water to the potable-water system would typically be of such design that it will produce potable water regularly. Seawater inlet lines should be located forward from the overboard discharge pipes. Provision would typically be made in the evaporator to prevent flooding.

It is important to ensure that high and low pressure units connected directly to the potable water lines have the ability to go to the waste system if the distillate is not fit for use. Units would typically have a low range salinity indicator, an operation temperature indicator, an automatic discharge to waste, and an alarm with trip setting or equivalent.

Distillation at high temperature close to the normal boiling point of water would likely eliminate all pathogens. However, reduced pressures are used in some desalination systems to reduce the boiling point and reduce energy demands. Temperatures as low as 50ºC may be possible. Spores and some viruses require higher temperatures and longer times for inactivation.

System assessment and hazard analysis

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 in distillation processes, especially of volatile toxic compounds.

A distillation plant or other process that supplies water to the ship's potable water system would typically not operate in polluted or harbour areas since some volatile pollutants may be carried through via this process.

Water production risk management

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. However, the absence of multiple barriers places great stress on the continuously safe operation of that process and implies that even short-term decreases in effectiveness may present significant risk to human health.

The nature of desalination units implies the need for highly reliable on-line monitoring linked to rapid management intervention. The units would typically be designed in such a way as to facilitate inspection for corrosion, pitting or leaks. The manufacturer's instructions would typically be posted near the distillation plant. A sufficient supply for replacement of any vital or fragile parts of the treatment apparatus would typically be available.

12.2.2 Loading water onto ships

The ship's master or officer responsible for the loading of water would typically be responsible for ascertaining whether or not the source of water is potable. When treatment or purification on board is necessary, the method selected would ideally be that which is best suited to the water to be treated, as recommended by the appropriate port authority, and which is most easily operated and maintained by ship's officers and crew.

Vessels using irregular ports, where water treatment is unreliable, may wish to carry equipment for basic testing (turbidity, pH, and chlorine residual) and ensure capacity to dose chlorine or filter to appropriate levels to provide a minimum level of safety.

Hoses used exclusively for the delivery of potable water would be kept on each ship. The ends would be capped when not in use. Keeper chains will prevent misplacement of caps. The hose needs to be so handled as to prevent contamination by dragging ends on the ground, pier or deck surfaces, or by dropping into the harbour water. A hose that has become contaminated would typically be thoroughly flushed and disinfected, for example as follows:

- flush the hose thoroughly with potable water;
- drain;
- raise both ends of the hose, fill with disinfecting solution approved by the health authority, close and allow to stand for 1 hour. A good solution is one containing 100 mg/L (100 ppm) of chlorine;
- drain the disinfecting solution; and
- flush thoroughly with potable water before attaching to filling line.

The hose would typically be flushed in all cases before attaching to the filling line. It can be drained after each use and stowed, with the ends capped, on reels or racks in special lockers.

River and canal waters need to be treated before use as potable water. Water drawn from shore sources and lake areas that are relatively free from contamination will be acceptable as potable water if properly disinfected. Seawater from clean areas is satisfactory for use in distillation equipment.

Water that is loaded from approved sources through clean, separate hoses and into properly constructed and maintained storage tanks might not require filtration. If filtration is necessary, it should be accomplished with approved types of pressure filters.

12.2.3 Water Storage on Ships

System assessment and hazard analysis

Important hazards and hazardous events associated with storage tanks include sediment build up at the bottom of the tank, damage to wire mesh in the vent/overflow pipe, ingress of contamination through points of physical damage, extraneous pollution during repair, leakage and cross connection during storage with non potable water tank/pipe.

Storage risk management

The ship operator needs to consider what control measures, if any, exist, which can be applied for the control of each hazard. Regular inspection, repair, cleaning and maintenance of storage tanks are important to ensure the water quality is not compromised.

Ship operators need to take special precautions when carrying out repairs to storage tanks. If such repairs are not carried out correctly they can pose their own threats. For example, an outbreak of typhoid on a ship occurred after the potable water was contaminated with sewage while the ship underwent repairs while in dry dock. This outbreak highlights the risk of gross contamination of the potable water supply during repair and maintenance and the need for good hygienic practice and post repair disinfection. Ship builders/rehabilitators would typically have written procedures for physical cleaning and disinfection before commissioning/recommissioning ships and also for vessel port repair.

Monitoring actions need to provide information in time to make adjustments to ensure control. Any deviation from the control measure must be corrected.

Examples of storage hazardous events, control measures, monitoring procedures and corrective actions is given in Table 2-3.

Table 2-3. Examples of storage hazardous events, control measures, monitoring procedures and corrective actions.

Hazardous event	Control measure	Monitoring procedures	Corrective action
Sediment at bottom of storage tanks	Routine cleaning e.g. every 6 months	Routine inspections, documentation	Procedure for cleaning storage tanks
Damage to wire mesh in overflow/vent pipe	Routine inspection, repair and maintenance	Routine sanitary inspections	Replace or repair
Cross connections between potable water storage tank and non potable water storage tank or pipe	Cross connection control programme	Routine inspections, repair and maintenance	Repair or replace
Defects in potable water storage tanks	Routine sanitary inspection.	Routine inspections, repair and maintenance	Repair or replace

12.2.4 Water distribution on Ships

System assessment and hazard analysis

The ship operators should take into account all hazards/hazardous events that may reasonably be expected to occur during distribution if not properly controlled. 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 check valves are introduced into the water system at sensitive points and pipes are free of leaks.

Repair work on a distribution system can offer several opportunities for widespread contamination of water supplies. The risks depend on factors such as the degree of pollution at the repair site, the method of repair, the ability to contain potential contamination by valving, and most importantly, the cleanliness of personnel, their working practices and the materials employed.

Hazards and hazardous events may include extraneous pollution in distribution systems by repairs to pipes or construction of new pipes (physical or microbiological contamination), back-siphonage caused by pressure drops combined with defective back-flow preventers or cracks and leaks, toxic substances leaching from pipes or contamination from non potable water *via* cross connections.

Microorganisms will normally grow in water, and on surfaces in contact with water as biofilms. Growth following drinking water treatment is normally referred to as “regrowth”. Growth is typically reflected in measurement of higher heterotropic plate counts (HPC) in water samples. Elevated HPC levels occur especially in stagnant parts of the piped distribution systems, and in plumbed in devices such as softeners, carbon filters and vending machines. The principal determinants of regrowth are temperature, availability of nutrients and lack of residual disinfectant. Although not overtly hazardous at lower temperatures where taste and odour formation might be the only concern, at warmer temperatures, *Legionella* might reach hazardous levels (described in Chapter 6).

Distribution risk management

Adequate repair of piping needs to be carried out and positive pressure would typically be maintained at all times. Routine sanitary inspections would typically cover checks for cross connections, defective pipes and defective back-flow preventers. Crew can be provided with training to take hygienic precautions when laying new pipes or repairing existing pipes. This training can cover details of the personal symptoms that indicate a potential waterborne disease. All staff should be encouraged to report such symptoms without prejudice to their employment practices. Crew need to provide adequate toilet and washing facilities to maintain personal hygiene. Known carriers of communicable diseases which can be waterborne should ideally not come into contact with potable water supplies. An adequate ratio of crew to the number of facilities is required to be present on board ship to enable proper servicing and maintenance activities. To reduce disease spread among crew, shared drinking receptacles are not safe for use on ships unless they are sanitised between use.

It is usual to maintain a disinfectant residual to control general bacterial proliferation in the water supplied to help reduce taste and odour formation and some forms of microbial influenced corrosion. In addition, this residual may kill very low levels of some pathogens that may gain entry to the network. However, such a residual is not adequate for large ingress events and should not be relied upon. The presence of the residual disinfectant does not mean that the water is necessarily safe. Similarly, the absence of a residual does not mean that the water is necessarily unsafe if the source is secure and distribution fully protected.

The absence of a residual where one would normally be found can be a useful indicator of gross contamination. However, many viral and parasitic pathogens are resistant to low levels of disinfectant so residual disinfection should not be relied upon to "treat" contaminated water. Low levels of residual may inactivate bacterial indicators such as *E. coli* and mask contamination that might harbour these more resistant pathogens.

Automated disinfection of the ship's potable water supply (including distillation system) can be more reliable than manual chlorination. Chlorine would be proportionally dosed according to the water quantity bunkered. It is also essential that the chlorine dosing drums be regularly checked to ensure that they are filled with the correct disinfectant at the correct dilution. Each drum would typically be checked before bunkering, at regular intervals during bunkering and after bunkering. All crew inspecting the drums and pumps need to be trained to identify faults that may occur and all observations would typically be recorded. Lessons learned from outbreaks include the need to assign explicit responsibility for the disinfectant residual testing as part of a WSP.

To prove disinfection is taking place, verification samples can be analysed using a suitable test kit. Test kits provided to calibrate analyzer-chart recorders and make measurements need to be capable of reading in suitable, such as no more than 0.2 mg/L, increments over a suitable, such as 0 to 5.0 mg/L, range. Records of readings would typically be recorded.

The ship's crew need to undertake, or commission, regular checks and tests on the adequacy of backflow prevention devices, possible cross connection points, leaks, defective pipes, pressure and disinfectant residuals. This may be best covered as part of a comprehensive sanitary inspection programme. Each backflow prevention device would typically be scheduled for inspection and service in accordance with the manufacturer's instructions and as necessary to prevent the device's failure.

For ongoing verification of water quality coliform bacteria are normally used to verify the absence of deterioration of water quality throughout storage and distribution systems. However, many species of bacteria in the coliform groups are common environmental bacteria and their value as an indicator of faecal contamination is limited. *E coli* is the only coliform bacterial species almost exclusively derived from the faeces of warm-blooded animals. Its presence in drinking water is interpreted as an indication of recent or substantial post-treatment faecal contamination or inadequate treatment.

Heterotrophic plate counts (HPCs) can be used as an indicator of general water quality within the distribution system. An increase in HPC indicates either post-treatment contamination, regrowth within the water conveyed by the distribution system or the presence of deposits and biofilms in the system. A sudden increase in HPCs above historic baseline values should trigger actions to investigate and, if necessary, remediate the situation.

Whenever the potable-water tanks and system or any of their parts have been placed in service, repaired or replaced, or have been contaminated, they would typically be cleaned, disinfected, and flushed before being returned to operation. Where a water distiller is connected to the potable-water tank or system, the pipe and appurtenances between the distiller and the potable-water tank or system would typically be disinfected.

Superchlorination treatment is typically applied so as to be sufficient to destroy the *Cryptosporidium* spp oocyts and hepatitis A virus. At this level of disinfection other disease organisms will be inactivated. Small dispensers for chlorination of the potable-water system or any part of the system are readily available. The chlorine solutions used for disinfection would typically have a strength of more than 50 mg/L (50 ppm) at the point of super chlorination. The contact time would typically be more than 24 hours, except in case of emergency when it may be reduced to as little as 1 hour given adequate concentration, provided the chlorine concentration is increased, for example, to around 100 mg/L (100 ppm) and maintained at that level throughout disinfection. The heavily chlorinated water would typically be drained and the system flushed with potable water before placing it in operation.

Boiling, an effective means of disinfection, is not generally practicable for use on ships, except for small quantities of water to be used for drinking, culinary or medical purposes in an emergency. Other means of disinfection, with the exception of chlorination, may require equipment that at present may be too large for ship installation and operation.

Examples of distribution hazardous events, control measures, monitoring procedures and corrective actions is given in Table 2-4.

Table 2-4. Examples of distribution system hazards/hazardous events, control measures, monitoring procedures and corrective actions.

Hazard	Control measure	Monitoring procedures	Corrective action
Cross connections with non potable water	Prevent cross connections Procedures for inspection, repair and maintenance Correct identification of pipes and tanks	Routine inspections	Break cross connection
Defective pipes, leaks	Procedures for inspection, repair and maintenance	Routine inspections	Repair pipes
Defective backflow preventers at outlets throughout distribution system	No defects that would allow ingress of contaminated water	Routine inspections Testing of preventers	Repair or replace
Contamination during repair and maintenance of tanks and pipes	No defects that would allow ingress into potable water tanks/pipes Procedures for hygienic repair and maintenance. Procedures for cleaning and disinfecting.	Inspection of job Water sampling (microbiological analysis)	Train staff Written procedures Disinfect fracture area and fitting

Hazard	Control measure	Monitoring procedures	Corrective action
Leaking pipes/tanks	Prevent leakage System maintenance and renewal	Routine inspections Pressure and flow monitoring	Repair
Toxic substances in pipe materials	No toxic substances Specifications for pipe materials	Check specifications for pipes and materials Check specification certificates	Replace pipes if specification is not correct
Insufficient residual disinfection	Adequate to prevent regrowth e.g. maintaining free chlorine residual above 0.2 mg/L	On line monitoring of residual, pH and temperature Routine sampling	Investigate cause and rectify

12.3 Food Safety

Food safety should be managed within the context of a Food Safety Plan (FSP; CAC 1997a, b; 1999; 2003; ISO 22000:2005) that covers both construction and operation of a ship and encompasses all process steps from source to consumer use. Familiarity and formal training in FSPs is an essential prerequisite to managing food safety aboard ship. Therefore, the generic aspects of FSPs are not described in this chapter although they are described in section 11.3.1.

12.3.1 Sources of food

All food would typically be obtained from shore sources approved or considered satisfactory by the relevant health administration. Food needs to be clean, wholesome, free from spoilage and adulteration, and otherwise safe for human consumption. Raw materials and ingredients should ideally not be accepted by the ship if they are known to contain parasites, undesirable microorganisms, pesticides, veterinary drugs or toxins, decomposed or extraneous substances which would not be reduced to an acceptable level by normal sorting and/or processing. Where appropriate, specifications for raw materials can be defined and applied. Stocks of raw materials and ingredients would typically be subject to effective stock rotation.

On delivery, checks can be carried out to ensure products meet specifications and that the means of transport from the supplier is satisfactory, e.g. clean, no possibility of contamination of the products owing to the carriage of non-food items, and, if necessary, temperature controlled.

12.3.2 Hygiene control systems

Inadequate food temperature control is one of the most common causes of foodborne illness and food spoilage on ships. On passenger ships the preparation of a wide variety of foods, at the same time, for a large number of people, increases the risk of mishandling and temperature abuse. For example, an outbreak of staphylococcal food poisoning on a cruise ship occurred after pastry was prepared in large quantities by several food handlers. This provided opportunities for the introduction of staphylococci into the pastry. Prolonged time at warm temperature allowed for production of enterotoxin.

In mass catering large numbers of people may require to be fed in a short space of time. It is often necessary to prepare food hours before it is needed and to hold food, under refrigeration, in a hot holding apparatus, or even at ambient temperature. If the procedures are strictly controlled and the storage temperatures are at levels that will not permit bacterial growth, then the levels of hazards can be adequately controlled.

The ship's operators would typically implement systems to ensure that temperature is controlled effectively where it is critical to the safety and suitability of food. Where appropriate, temperature-recording devices can be checked at regular intervals and tested for accuracy by the crew.

Food should ideally not be left for long periods at ambient temperature, or placed in hot-holding equipment not preheated or set at too low a temperature, or reheated by addition of hot gravy or sauce.

Refrigerators would typically be kept clean and in good repair. Sufficient shelving is needed in all refrigeration units to prevent stacking and to permit adequate ventilation and cleaning.

Examples of typical recommended temperatures for perishable food storage include the following:

- Food to be held hot would typically be placed in a hot-holding apparatus already at a temperature of at least 62.8ºC (145ºF) and maintained at that temperature until required.

- All perishable food or drink would typically be kept at or below 4ºC (40ºF) except during preparation or when held for immediate serving after preparation. When such foods are to be stored for extended periods, a temperature of 4ºC (40ºF) is recommended. Fruits and vegetables would typically be stored in cool rooms. Ideally, meat and fish would typically be maintained at 0 to 3ºC (32 to 37ºF), milk and milk products at 4ºC (40ºF) and fruit and vegetables at 7-10ºC (45 to 50ºF). For more practical purposes, if there are limited refrigerated spaces, meat and meat products, fish and fish products, milk and milk products and eggs and egg products can be stored at < 5ºC (41ºF) whilst fruit and vegetables can be stored at < 10ºC (50ºF).

- Frozen foods would typically be kept below -12ºC (10ºF).

When foods are undercooked or inadequately thawed, particularly large joints of meat or poultry, and especially large frozen turkeys, with cooking times too short and temperatures too low, salmonellae and other organisms may survive. Subsequent poor storage will permit multiplication. It is important that large joints of meat and poultry are thawed out before cooking. Precautions need to be taken to cool cooked food quickly and to cold store those not to be freshly cooked.

Pathogens can be transferred from one food to another, either by direct contact or by food handlers, contact surfaces or the air. Space is sometimes limited in galleys preventing the clear separation of raw and cooked foods. In an outbreak of *Escherichia coli* gastroenteritis, in 1983, multiple contaminated cold buffet foods, served over several days, were implicated.

Raw food, especially meat, needs to be effectively separated, either physically or by time, from ready to eat foods, with effective intermediate cleaning and where appropriate, disinfection. Surfaces, utensils, equipment, fixtures and fittings would typically be thoroughly cleaned and where necessary disinfected after raw food, particularly after meat and poultry, has been handled.

Systems would typically be in place to prevent contamination of foods by foreign bodies such as glass or metal shards from machinery, dust, harmful fumes and unwanted chemicals, particularly after any maintenance work.

Ice that will come in contact with food or drink needs to be manufactured from potable water. Shore sources must be checked with the local health authority and delivery of ice from shore to ship must be carried out in a sanitary manner. Upon delivery to the ship, shore ice needs to be handled (including washing with potable water) in a sanitary manner, the handler wearing clean clothing, gloves and boots and using clean equipment. Ice would typically be stored in a clean storage room and raised off the surface by use of deck-boards or similar devices permitting drainage and free flow of air. Ice manufactured on board ship needs to be handled and stored in a sanitary manner. Ice can be washed with potable water before coming in contact with food and water.

12.3.3 Maintenance and sanitation

Cleaning and disinfection programmes ensure that all parts of the establishment are appropriately clean, and include the cleaning of cleaning equipment. Cleaning and disinfection programmes can be continually and effectively monitored for their suitability and effectiveness and where necessary, documented.

Cleaning can remove food residues and dirt, which may be a source of contamination. The necessary cleaning methods will depend on the nature of the catering and size of the ship. Disinfection may be necessary after cleaning. Cleaning chemicals would typically hould be handled and used carefully and in accordance with manufacturers' instructions and stored, where necessary, separated from food, in clearly identified containers to avoid the risk of contaminating the food. Galley and food areas and equipment need to be kept in an appropriate state of repair and condition to:

- facilitate all sanitation procedures;
- function as intended, particularly at critical steps; and
- prevent contamination of food e.g. from debris and chemicals

Cleaning can be carried out by the separate or the combined use of physical methods, such as heat, scrubbing, turbulent flow, vacuum cleaning or other methods that avoid the use of water, and chemical methods using detergents, alkalis or acids. Cleaning procedures will involve, where appropriate:

- removing gross debris from surfaces;
- applying a detergent solution to loosen soil and bacterial film and hold them in solution or suspension;
- rinsing with potable water to remove loosened soil and residues of detergent; and
- where necessary, disinfection.

Where written cleaning programmes are used, they might specify:

- areas, equipment and utensils to be cleaned;
- cleaning materials/equipment and chemicals to be used;
- who is responsible for particular tasks;
- methods, including the dismantling and re-assembly of equipment, where appropriate;
- safety precautions;
- frequency of cleaning and monitoring arrangements; and.
- the standard(s) to be achieved.

In addition, there may, at times, be deep cleaning, such as at six-monthly or annual intervals, subject to usage and the specific area, e.g. ducting and extraction systems. Cleaning programmes might also be in place for environmental cleaning, with appropriate facilities for cleaning the cleaning materials (See also Section 7.3.3).

Residual and space sprays are effective for the control of insects. However, during spraying operations all foodstuffs, utensils and food preparation and cleansing equipment may need to be covered to protect them from toxic substances. Instructions for the use of sprays should be carefully followed. Insecticides and rodenticides, and any poisonous substances, and equipment for their use would typically not be stored in or immediately adjacent to spaces used for the storage, handling, preparation and serving of food and drink, for the cleansing or storage of dishes and utensils, or for the storage of tableware, linen and other equipment used for the handling and serving of food and drink. As a further precaution to prevent the accidental use of these poisons in foodstuffs, such hazards might be kept in coloured containers marked with words such as “POISON”.

12.3.4 Personal hygiene

Crew, including maintenance personnel, who do not maintain an appropriate degree of personal cleanliness, who have certain illnesses or conditions or who behave inappropriately, can contaminate food and transmit illness to consumers.

Some outbreaks of food poisoning on ships were associated with a lack of hygienic facilities onboard ship. Conveniently located hand washing and toilet facilities are a prerequisite for hygienic handling of food. In an outbreak of multiple antibiotic resistant *Shigella flexneri* 4a spread of the infection by an infected food handler may have been facilitated by limited availability of toilet facilities for the galley crew. Some older vessels do not have any toilet facilities for use by galley workers while they are on duty.

Food handlers need to maintain a high degree of personal cleanliness and, where appropriate, wear suitable protective clothing, head covering, and footwear. Cuts and wounds, where personnel are permitted to continue working, would typically be covered by suitable waterproof dressings.

Protective clothing should ideally be light-coloured, without pockets and not one-piece overalls, as these could become contaminated from the floor when using the lavatory. Disposable gloves might be used in some food handling situations for specific purposes, however they can be misused and give food handlers a false sense of hygiene security and therefore should be disposed of after any specific use, e.g. after handling prepared ready-to-eat foods or money (see also Section 7.1).

Personnel need to wash their hands when personal cleanliness may affect food safety, for example:

- at the start of food handling activities;
- immediately after using the toilet; and
- after handling raw food or any contaminated material, where this could result in contamination of other food items they should avoid handling ready to eat food or money, where appropriate.

People engaged in food handling activities would typically refrain from behaviour which could result in contamination of food such as:

- smoking;
- spitting;
- chewing or eating; and
- sneezing or coughing over unprotected food.

Personal effects such as jewellery, watches, pins or other items would typically not be worn or brought into food handling areas if they pose a threat to the safety of food.

Crew known, or suspected, to be suffering from, or to be a carrier of a disease or illness likely to be transmitted through food, would typically not be allowed to enter any food handling areas if there is likelihood of their contaminating food. Any person so affected needs to immediately report illness or symptoms of illness. In one outbreak of foodborne viral gastroenteritis six foodhandlers were ill but were reluctant to report their infections because of concern about job security. The outbreak investigation implicated fresh cut fruit salad at two buffets. This is a difficult issue to resolve because food handlers may deny that they are ill for fear of being penalised. Even once symptoms of illness have abated, people can remain infectious, or symptoms may reappear. Therefore, food handlers should ideally not begin working with food for a suitable period, at least 48 hr, following the cessation of symptoms. In practice, this recommendation is purely practical since people can remain infectious for weeks, albeit at a reducing level, following the abatement of symptoms. Therefore, recently ill food handlers should be encouraged to take extra precautions.

Conditions which should be reported to management so that any need for medical examination and/or possible exclusion from food handling can be considered, include:

- jaundice;
- diarrhoea;

- vomiting;
- fever;
- sore throat with fever;
- visibly infected skin lesions (boils, cuts etc); and
- discharges from the ear, eye or nose.

New food handling staff can be asked questions about their state of health and all food handling staff can be asked about their state of health after a period of leave. Possible questions include those found in the "Guidance for Food Businesses, Enforcement Officers and Health Professionals, Department of Health, UK, 1995" which provides questions to ask employees when considering employing new food handlers or reinstating food handlers after any extended shore leave:

1. Have you now, or have you over the last seven days, suffered from diarrhoea and/or vomiting? (Yes/No)
2. At present, are you suffering from:
   (i) skin trouble affecting hands, arms or face? (Yes/No)
   (ii) boils, styes or septic fingers? (Yes/No)
   (iii) Discharge from eye, ear or gums/mouth? (Yes/No)
3. Do you suffer from:
   (i) recurring skin or ear trouble? (Yes/No)
   (ii) a recurring bowel disorder? (Yes/No)
4. Have you had, or are you now known to be a carrier of, typhoid or paratyphoid fever? (Yes/No)
5. In the last 21 days have you been in contact with anyone, who may have been suffering from typhoid or paratyphoid fever? (Yes/No)

12.3.5 Training

Those engaged in food preparation or who come directly or indirectly into contact with food need to be trained, and/or instructed in food hygiene to a level appropriate to the operations they are to perform.

Food hygiene training is fundamentally important. All personnel need to be aware of their role and responsibility in protecting food from contamination or deterioration. Food handlers need to have the necessary knowledge and skills to enable them to handle food hygienically. Those who handle strong cleaning chemicals or other potentially hazardous chemicals would typically be instructed in safe handling techniques. This includes maintenance personnel who enter food handling areas in order to undertake their work. It is not essential that such employees are trained in all food hygiene matters, but they should have an awareness of the relevant hygiene aspects appropriate to their work.

Periodic assessments of the effectiveness of training and instruction programmes would typically made, as well as routine supervision and checks to ensure that procedures are being carried out effectively.

Managers and supervisors of food processes need to have the necessary knowledge of food hygiene principles and practices to be able to judge potential risks and take the necessary action to remedy deficiencies.

The "UK Industry Guide to Good Hygiene Practice: Catering Guide – Ships" provides a checklist called the "Food Hygiene Supervision and Instruction and/or Training" on the Essentials of Food Hygiene which forms the basis of the following training outline:

All crew should be properly supervised and instructed to ensure they work hygienically. A greater degree of supervision may be needed for:

- new crew awaiting formal training;
- crew handling high risk foods;
- less experienced crew; and
- crew whose first language is not the same as that spoken by others on the ship and/or crew with learning or literacy difficulties.

When a ship's operation or part of the operation employs only one or two people, supervision may not be practical. In such cases, training and levels of competence must be sufficient to allow work to be unsupervised.

All food handlers should, before starting work for the first time, receive written or verbal instruction in the essentials of food hygiene, viz:

- keep yourself clean and wear clean clothing;
- keep hair and beards trimmed and covered;
- always wash your hands thoroughly: before handling food or starting work, after using the toilet, handling raw foods or waste, after every break, after blowing your nose, eating, drinking or smoking.
- tell your supervisor, before commencing work, of any skin, nose, throat, stomach or bowel trouble, fever or infected wound;
- ensure cuts and sores are covered with a waterproof, high visibility dressing;
- avoid unnecessary handling of food;
- do not smoke, eat or drink in a food room, and never cough or sneeze over food;
- if you see something wrong, tell your supervisor;
- do not prepare food too far in advance of service;

- keep perishable food either refrigerated or piping hot;
- keep the preparation of raw and cooked food strictly separate;
- when reheating food ensure it gets sufficiently hot throughout;
- clean as you go. Keep all equipment and surfaces clean. Follow the cleaning programmes; and
- follow all food safety instructions in any of the ship's operational manuals or on food packaging or from your supervisor;

As some of the above points may not be relevant to all vessels and operations, they should be amended accordingly to suit the operation.

All relevant crew should have Hygiene Awareness Instruction. The topics covered should be appropriate to the job of the individual and may include:

- the ship operator's policy with priority given to food hygiene and safety;
- harmful bacteria;
- personal health and hygiene stressing the need for high personal standards, reporting illness, etc;
- cross-contamination causes and prevention;
- food storage protection, temperature control;
- waste disposal, cleaning, sanitation and disinfection materials, methods and storage;
- 'foreign body' hazards and potential contamination; and
- awareness of pests liable to be encountered on board and relevant action to be taken.

In addition, crew must be told how to do their particularly job hygienically. In particular, they should be instructed on any control or monitoring points of the HACCP plan.

The depth, breadth and duration of training will be dependent upon the particular job role and the degree of risk involved in the activity.

The first level of training aims to give a level of understanding on the basic principles of food hygiene and the course may be of about 6 hours duration. The following topics should be covered:

- food poisoning micro-organisms types and sources;
- simple microbiology, toxins, spores, growth and destruction;
- food operation areas and equipment;
- common food hazards: physical, chemical and microbiological;

- personal hygiene: basic rules and responsibilities;
- preventing food contamination and spoilage;
- food poisoning, symptoms and causes;
- cleaning and disinfection/sterilisation;
- legal obligations;
- pest awareness; and
- effective temperature control of food, e.g. chilled or frozen storage, thawing, cooking, cooling, reheating and holding.

More advanced training courses should deal with management and systems, including HACCP.

12.3.6 Vending machines

Vending machines should not be overlooked and the same principles apply to these as other units for storing and supplying food. The following provides a summary of key points from the "UK Industry Guide to Good Hygiene Practice: Vending and Dispensing Guide Supplement" (To the Catering Guide 1995):

Where automatic drink or snack/meal dispensing machines are provided on certain types of passenger vessels, it is necessary to consider food safety and hygiene aspects and the appliances should be included in any HACCP plan. The types of machines can be categorised according to the products available.

- prepacked shelf stable food/drinks, which are ready for consumption;
- drinks: (premix or postmix) such as hot drinks, coffee, tea, chocolate, soups, soft drinks, fruit juices and ice cubes;
- drinks containing dairy products: milkshakes, yoghurts, chocolate milk;
- fresh/Prepared Foods: defrosted foods, hot snacks such as meat pies, fresh prepared ice cream, sandwiches, cold snacks with meat, fish, eggs, etc; and
- prepared meals which are stored and chilled and reheated in a microwave oven.

Aspects to consider relative to the type of machine include the following:

- Installation: is the machine so installed that it will allow easy cleaning of the machine and surrounding area and prevent pest harbourage?
- Water supply: is the supply potable?
- Is the cleaning programme satisfactory?
- Is the machine being used for the purpose for which it was designed, i.e. perishable foods not kept in machines designed for ambient stable foods?

- Are procedures in place for proper stock rotation?
- Are temperatures checked on a daily basis?
- Are foods replenished frequently and the shelf life of food remaining in the machine satisfactory?

12.4 Recreational water environments

The primary water and air quality health challenges to be dealt with are:

- controlling clarity and other factors that minimize injury hazard;
- controlling water quality to prevent transmission of infectious disease; and
- controlling potential hazards from disinfection by-products.

This requires sound operational management of:

- treatment (to remove particulates, pollutants and microorganisms);
- disinfection (to destroy or remove infectious microorganisms as that the water cannot transmit disease-causing biological agents);
- pool hydraulics (to ensure optimal distribution of disinfection throughout the pool); and
- addition of fresh water at frequent intervals (to dilute substances that cannot be removed from the water by treatment). Pool operators should replace pool water as a regular part of their water treatment regime. To some extent, dilution can be performed through the replacement of water run to waste during filter backwashing or by replacement of pool water used for pre-swim foot spas and other cleaning purposes.

12.4.1 Clarity

Controlling clarity involves adequate water treatment, usually involving filtration and coagulation. The control of pathogens is typically achieved by a combination of recirculation of pool water through treatment (typically involving some form of filtration plus disinfection) and the application of a residual disinfectant to inactivate microorganisms introduced to the pool by bathers.

12.4.2 Pool hygiene

As not all infectious agents are killed by the most frequently used residual disinfectants, and as removal in treatment is slow, it is necessary to minimize accidental faecal releases (AFRs) and vomitus and to respond effectively to them when they occur. The use of pre-swim showers is of use in minimizing the introduction of shed organisms. Therefore, all users would typically be encouraged to use toilets and showers before bathing to minimize contamination of the pool.

Where pre-swim showering is required, pool water is clearer, easier to disinfect with smaller amounts of chemicals and thus more pleasant to swim in. Operators need to be satisfied that the water supplied for the showers is microbiologically satisfactory.

AFRs appear to occur relatively frequently, and it is likely that most go undetected. A pool operator faced with an AFR or vomitus in the pool water needs to act immediately.

If a faecal release is a solid stool, it can simply be retrieved quickly and discarded appropriately. The scoop used to retrieve it would typically be disinfected so that any bacteria and viruses adhering to it are inactivated and will not be returned to the pool the next time the scoop is used. As long as the pool is in other respects operating properly (disinfecting residuals, etc) no further action is necessary.

If the stool is runny (diarrhoea) or if there is vomitus, the situation is potentially hazardous. Even though most disinfectants deal relatively well with many bacterial and viral agents in AFRs and vomitus, the possibility exists that the diarrhoea or vomitus is from someone infected with one of the protozoan parasites, *Cryptosporidium* and *Giardia*. The infectious stages (oocysts/cysts) are relatively resistant to chlorine disinfectants in the concentrations that are practical to use. The pool would typically therefore be cleared of bathers immediately.

The safest action, if the incident has occurred in a small pool, hot tub or whirlpool, is to empty and clean it before refilling and reopening. However, this may not be possible in larger pools.

If draining down is not possible, then the procedure given below - an imperfect solution that will only reduce but not remove risk – can be followed:

- the pool is cleared of people immediately;
- disinfectant levels are maintained at the top of the recommended range;
- the pool is vacuumed and swept;
- using a coagulant, the water is filtered for six turnover cycles. This could take up to a day and so might mean closing the pool until the next day;
- the filter is backwashed (and the water run to waste); and
- the pool can then be reopened.

There are a few practical actions pool operators can take to help prevent faecal release into the pools:

- no child (or adult) with a recent history of diarrhoea should swim;
- parents should be encouraged to make sure their children use the toilet before they swim;
- thorough pre-swim showering is a good idea and parents should encourage their children to do it;
- young children should whenever possible be confined to pools small enough to drain in the event of an accidental release of faeces or vomitus; and
- lifeguards should be made responsible for looking out for and acting on AFR/vomitus.

Microbial colonisation of surfaces can be a problem and is generally controlled through cleaning and disinfection such as shock dosing and cleaning.

12.4.3 Spa pools

Spa pools have different operating conditions and present a special set of problems to operators. The design and operation of these facilities make it difficult to achieve adequate disinfectant residuals. They may require higher disinfectant residuals because of higher bathing loads and higher temperatures, both of which lead to more rapid loss of disinfectant residual.

Hot tubs and whirlpools and associated equipment can create an ideal habitat for the proliferation of *Legionella* and *Mycobacteria*. In addition, *P. aeruginosa* is frequently present in whirlpools and skin infections have been reported when the pool design or management is poor.

A *P. aeruginosa* concentration of less than 1 per 100 ml should be readily achievable through good management practices. Risk management measures that can be taken to deal with these non-enteric bacteria include ventilation, cleaning of equipment and verifying the adequacy of disinfection.

Spa pools that do not use disinfection require alternative methods of water treatment to keep the water microbiologically safe. A very high rate of water exchange is necessary - even if not effective enough - if there is no other way of preventing microbial contamination.

In spa pools where the use of disinfectants is undesirable or where it is difficult to maintain an adequate disinfectant residual, superheating spa water to 70ºC on a daily basis during periods of non use may help control microbial proliferation.

To prevent overloading of spa pools, some countries recommend that clearly identifiable seats be installed for users combined with a minimum pool volume being defined for every seat, a minimum total pool volume and a maximum water depth.

Pools and hot tubs on ships may use either seawater or potable water as the source water. The hydraulic and circulation system of the pool will necessitate a unique pool design, depending upon ship size and pool location. The filtration and disinfection systems will also require adaptation to the water quality. Flow through seawater pools on cruise ships may become contaminated by polluted water in harbour areas and risk contamination from sewage discharge

12.4.4 Monitoring

Parameters that are easy and inexpensive to measure and of immediate health relevance - that is, turbidity, disinfectant residual and pH – can be monitored frequently and in all pool types.

Turbidity

The ability to see either a small child at the bottom of the pool or lane markings or other features on the pool bottom from the lifeguard position while the water surface is in movement, as in normal use, can be converted to turbidity equivalents and monitored routinely. The turbidity equivalents can be compared with 0.5 nephelometric turbidity units (NTU), which is a useful upper limit guideline for optimized water treatment. If these turbidity equivalents are higher than 0.5 NTU, the lower, more stringent guidelines of 0.5 NTU can be used.

To exceed turbidity limits suggests both a significant deterioration in water quality and a significant health hazard. Such exceedance merits immediate investigation and may lead to facility closure pending remedial action.

Disinfectant and pH

For chlorine-based disinfectants, adequate routine disinfection would typically be achieved with a free chlorine residual level of at least 1 mg/L throughout the pool. In a well-operated pool it is possible to achieve such a residual with maximum levels in any single point below 2 mg/L for public pools and 3 mg/L for semi-public pools. Lower residuals (0.5 mg/L) will be acceptable in combination with the additional use of ozone, whereas higher levels (2-3 mg/L) may be required for spa and hydrotherapy pools.

Disinfectant residuals would typically be checked by sampling the pool before it opens and after closing. The frequency of testing during swimming pool use depends upon the nature and use of the swimming pool. Samples should be taken at various parts of the pool, including the area of the pool where disinfectant residual is lowest. If the routine test results are outside the recommended ranges, the situation needs to be assessed and action taken.

The pH value of swimming pool water needs to be maintained within the recommended range to ensure optimal disinfection and coagulation. In order to do so, regular pH measurements are essential, and either continuous or intermittent adjustment is usually necessary. For heavily used pools, the pH value would typically be measured continuously and adjusted automatically. For less frequently used pools, it may be sufficient to measure the pH manually.

The method of introducing disinfectants to the pool water influences their effectiveness. Individual disinfectants can have their own specific dosing requirements, but the following principles apply to all:

- Automatic dosing is preferable: electronic sensors monitor pH and residual disinfectant levels continuously and adjust the dosing correspondingly to maintain correct levels. Regular verification of the system (including manual tests on pool water samples) and good management are important.
- Hand dosing (i.e. putting chemicals directly into the pool) is rarely justified. Manual systems of dosing must be backed up by good management of operation and monitoring. It is important that the pool is empty of bathers until the chemical has dispersed.
- Trying to compensate for inadequacies in treatment by shock dosing is bad practice, because it can mask deficiencies in design or operation that may produce other problems and can generate unwelcome by-products.
- Dosing pumps should be designed to shut themselves off if the circulation system fails (although automatic dosing monitors should remain in operation) to ensure that chemical dispersion is interrupted.
- Residual disinfectants are generally dosed at the very end of the treatment process. The treatment methods of flocculation, filtration and ozonation serve to clarify the water, reduce the organic load and greatly reduce the microbial count, so that the post-treatment disinfectant can be more effective and the amount of disinfectant that must be used can be minimized.
- It is important that disinfectants and pH adjusting chemicals be well mixed with the water at the point of dosing.

- Dosing systems, like circulation, should continue 24 h per day.

Microbiological quality

Microbiological monitoring at varying frequencies is often undertaken as a means of verification. Microbial quality would typically be checked before a pool is used for the first time, before it is put back into use after it has been shut down for repairs or cleaning and if there are difficulties with the treatment system or when contamination is suspected. Routine testing for *P. aeruginosa* in spa pools is also recommended.

Control of disinfection by-products.

To avoid excessive disinfectant by-product or disinfectant irritation to mucosal surfaces, disinfectant residuals should be maintained at levels that are consistent with satisfactory microbiological quality but that are not unnecessarily excessive. Operators should attempt to maintain free chlorine residual levels below around 5 mg/L at all points in the pool or spa.

The production of disinfection by-products can be controlled to a significant extent by minimizing the introduction of their organic precursors (compounds that react with the disinfectant to yield the by-products) through good hygienic practices (pre-swim showering), and maximizing their removal by well managed pool water treatment. The control of disinfectant by-products involves dilution, pre-swim showering, treatment and disinfection modification or optimization. Because of the presence of bromide ions in salt water, a common by-product formed in the water and air of seawater pools on ships will be bromoform which can result from either chlorine or ozone treatment.

It is inevitable that some volatile disinfectant by-products will be produced in the pool water and escape into the air. This hazard can be managed to some extent through good ventilation.

12.5 Ballast water and waste management and disposal

The prevention, minimization and elimination of health risks arising from wastes produced aboard ships depend on both the implementation of a waste management plan on board as well as on the appropriate port reception facilities. Waste storage and disposal must be carried out according to international standards, and appropriate facilities and equipment must be available for use in every ship or port.

12.5.1 Liquid wastes and ballast water

Ships are not generally permitted to discharge sewage, ballast water, bilge water or any other liquid containing contaminating or toxic wastes within an area from which water for a water supply is drawn, or in any area restricted for the discharge of wastes by any national or local authority. Overboard discharge in harbours, ports and costal waters is subject to the regulations of the governing authorities in these areas. Sewage, food particles, putrescible matter and toxic substances would typically also not be discharged to the bilge.

Any country may provide special barges for the reception of these wastes or shore connections to receive these wastes into a sewer system. Where the shore servicing area or barge does not provide hose or connections to receive these wastes, the ship would typically provide a special hose and connections large enough to allow rapid discharge of wastes. This hose would typically be durable, impervious, and with a smooth interior surface, it would be of a size different from that of the potable water hose or other water filling hoses, and it could be labelled, for example, as “FOR WASTE DISCHARGE ONLY”. After use, the hose can be cleaned by thorough flushing with clear water, and stored in a convenient place, labelled, for example, “WASTE DISCHARGE HOSE”.

The prohibition against discharge of wastes near a water supply intake or in any body of water where measures for the prevention and control of pollution are in force will require the provision of retention tanks or sewage treatment equipment on board.

Drain, soil and waste pipes need to be maintained frequently to prevent clogging and the backflow of sewage and bath water or contaminated wastes into the fixtures and spaces served by the collection system. Sewage, food particles, putrescible matter and toxic substances would typically not be discharged to the bilge. Sewage, ballast water, bilge water or any other liquid containing contaminating or toxic wastes would typically not be discharged within an area from which water for a water supply is drawn, and cannot be discharged in any area restricted for the discharge of wastes by any national or local authority or under international regulations.

In some cases, water from lakes may be satisfactory for use as wash-water without treatment when drawn from areas not affected by contaminated drainage from shore, ship or small craft, including pleasure craft. If in doubt, and in all cases where water is drawn from rivers and canals, water ought to be drawn from the least contaminated areas and would typically be filtered and disinfected prior to use. The areas from which wash-water may be drawn and the extent of filtration and disinfection required are typically established by the national health administration. If grossly contaminated water is required for emergency use as wash-water, it would need to be adequately treated.

12.5.2 Overboard discharge of waste and ballast water

Overboard discharge of waste should be done according to the Annex V of MARPOL, Resolution A.868 (20), International Convention for the Control and Management of Ships' Ballast Water and Sediments, and any national regulations.

Barges and/or trucks for the reception of liquid wastes, or shore connections at ports to receive these wastes into a sewer system, are typically provided at ports. Where the port servicing area or barge does not provide a hose and suitable connections to receive liquid wastes from a ship, a ship would typically provide a special hose and connections large enough to allow rapid discharge of the wastes to sewer or other suitable point. This hose needs to be durable, impervious, and with a smooth interior surface. It can be of a fitting different from that of the potable water hose or other water filling hose, and it can be labelled, for example, “FOR WASTE DISCHARGE ONLY”. After use, the hose can be cleaned, disinfected and stored in a convenient place, labelled, for example, “WASTE DISCHARGE HOSE”. It is generally forbidden to dispose of liquid waste around port areas, in compliance with the exceptions set forth on Rule 9 of MARPOL Annex IV and in compliance with what is established in the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

12.5.3 Wastes requiring treatment

All ships would typically be equipped with facilities for managing wastes from toilets and urinals, faecal material from hospital facilities and medical care areas, and wastes from food-refuse grinders. These facilities include either treatment facilities and/or safe holding tanks, properly equipped with pumps and piping. Wastes from safe holding tanks may be discharged to connections in the ports or to special barges or trucks for the reception of these wastes. The design of treatment facilities and waste holding tanks needs to be based on a suitable volume, for example 114 L (30 USG) per capita per day of liquid waste. Connections need to comply with Rule 11 of MARPOL Annex IV, as for theirs external and internal diameters, centre to centre diameters, and other aspects in the rule.

12.5.4 Galley wastes

All galley wastes, exclusive of ground refuse, that may contain grease would typically be made to flow through grease interceptors (grease traps) to a retaining box prior to discharge overboard after a suitable separation distance, such as 3 NM from the closest line of land (territorial sea – 12 NM), or in compliance with other national rules, or to treatment aboard ship. The grease collected may be disposed of by incineration, by storage for shore disposal, or by overboard discharge on the high seas.

12.5.5 Excess sludge

Excess sludge is typically stored for appropriate disposal to land based facilities or when on the high seas.

12.5.6 Food wastes

Food wastes and refuse readily attract rodents and vermin, particularly flies and cockroaches. The proper retention, storage and disposal of such wastes on board, on shore, and overboard where shore areas will not be affected, will prevent the creation of health hazards and public nuisances.

All ships would typically be equipped with facilities for safe storage of food refuse. All food refuse would typically be received and stored in watertight, non-absorbent and easily cleaned containers, fitted with tight covers which should be closed during food preparation, food serving and cleansing operations in food-handling spaces. These containers can be placed in waste storage spaces, specifically constructed and used for this purpose, or on open decks when necessary. After each emptying, each container would typically be thoroughly scrubbed, washed, and treated with disinfectant, if necessary, to prevent odours and nuisances and to minimize attraction of rodents and flies and cockroaches. Containers would ideally not be left uncovered except during the necessary food handling and clean up procedures.

It is important to characterise the waste stream and the amount of wastes produced in galleys and related areas in order to provide a basis for planning to prevent environmental contamination. People in charge of the waste collection ought to utilize personal protection equipment including special disposable gloves, face shield, masks and/or protective eyewear, safety boots/shoes and resistant suit, gowns, laboratory coats or aprons.

12.5.7 Dry refuse

Dry refuse can be stored in tightly covered bins, or in closed compartments, protected against the weather and the entry of rodents, flies and cockroaches. The containers can be thoroughly cleaned after emptying to discourage harbourage of rodents and vermin.

12.5.8 Healthcare wastes

All ships should be equipped with facilities for treating and/or safely storing healthcare wastes. Healthcare waste is any waste generated during patient diagnosis, treatment or immunization. Healthcare waste is of two categories: infectious and non infectious. Infectious healthcare waste is liquid or solid waste that contains pathogens in sufficient numbers and with sufficient virulence to cause infectious disease in susceptible hosts exposed to the waste. Non infectious healthcare waste includes disposable healthcare supplies and materials that do not fall into the category of infectious healthcare waste.

Infectious waste can be safely stored or sterilized, e.g. by steam, and suitably packaged for ultimate disposal ashore. Healthcare waste should ideally be clearly labelled. Ships properly equipped may incinerate paper and cloth based healthcare waste but not plastic and wet materials. Sharps can be collected in plastic autoclavable sharps containers and retained on board for ultimate disposal ashore. Unused sharps can be disposed of ashore in the same manner as healthcare waste.

Liquid healthcare wastes may be disposed of by discharging them into the sewage system. Non infectious healthcare waste may be disposed of as garbage if they do not require steam sterilizing or special handling. Staff dealing with health care wastes can be immunised against hepatitis B virus.

12.5.9 Pharmaceutical wastes

The management of pharmaceutical wastes produced aboard can be carried out appropriately in order to prevent harm to the environment and human health. Specific considerations for pharmaceutical wastes include avoidance of disposing of non-biodegradable products, or products that might harm bacteria involved in wastewater treatment, into the sewage system and avoiding burning pharmaceuticals at low temperatures or in open containers.

12.5.10 Training

Staff at ports and ship crews need to be adequately trained in the protection of the environment, safe operation, and relevant legislation. People involved in the collection, handling and disposal of wastes need to be trained in the relevant legislation and the risks posed by wastes.

12.6 Legionnaires' disease

Whilst acknowledging that it is not practical to completely remove *Legionella* bacteria from all the wet environments of a ship, it is practical to reduce their numbers to levels that make the contraction of legionellosis on board ship highly unlikely.

12.6.1 Drinking water

The occurrence in high numbers in drinking water supplies is preventable through the implementation of basic water quality management measures, including treatment of source water if it is non-potable, maintaining piped water temperatures outside the range that *Legionella* proliferates (25 to 50ºC) and/or through the maintenance of disinfection residuals throughout the piped distribution system and storage tanks. *Legionella* spp can proliferate due to factors within the ship environment even if there are low concentrations in the water that was initially taken aboard ship and even if loaded water conformed with the recommendations of the IHR and GDWQ. Management of *Legionella* in a ship's piped distribution system requires the implementation of management practices, which may include:

- treating water for potability if it is uplifted from a non potable or suspect source;
- maintaining a disinfectant residual in the distribution system;
- setting of heaters to ensure hot water is delivered to all taps at or above 50ºC; and
- insulating all pipes and storage tanks to ensure that water is maintained outside the temperature range 25 to 50ºC.

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

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

Periodic maintenance and cleaning of water storage tanks and pipes, particularly low flow areas and system extremities, can be carried out at appropriate frequencies and involves draining, physical cleaning and biocide treatment. Water flow in the distribution system can be maintained during periods of reduced activity. Backflow prevention devices and thermostatic mixing valves need to be maintained regularly to prevent the creation of zones of warm water that could support *Legionella* proliferation.

Appropriately qualified plumbers would typically undertake necessary maintenance of plumbing systems to prevent cross-connections of hot and cold pipes that may lead to the creation of warm water zones that could support *Legionella* proliferation.

Once installed and operational, ongoing and appropriately frequent monitoring of control measures is required to ensure that the system is operating as intended and to provide early warning of deviations. This may include:

- monitoring temperature, including monitoring of remote areas frequently;
- inspecting thermal lagging of pipes;

- monitoring biocide or disinfectant concentration and associated pH;
- inspecting pipes and storage tanks to check for cross connections and leaks;
- inspection of backflow preventers; and
- undertaking microbial testing.

12.6.2 Recreational water environments

In recreational water environments it is impractical to maintain temperatures outside the range 25 to 50ºC. However *Legionella* levels can be kept under control through the implementation of appropriate management measures, including filtration and maintenance of a continuous disinfection residual in recreational water environments, and the physical cleaning of all spa pool equipment including associated pipes and air-conditioning units. Therefore, it is necessary to design and implement a range of other management strategies, which may include:

- Add biocides to the spa water, plumbing, and filter. Free residual chlorine levels in spa water can be in the range 3 to 10 mg/L (although in some areas there are upper limits, such as in Germany, a maximum of 1mg/L is allowed) and bromine levels in the range 4 to 10 mg/L. To ensure that free halogen is effective for disinfection, there is a need to maintain or regularly adjust the pH, typically remaining in the range 7.2 to 7.8.
- Ensure staff hold appropriate qualification and competency to operate the recreational facility.
- Apply a constant circulation of water in the whirlpool and spa pool.
- Cleaning filter systems, e.g. by back-washing filters.
- Clean pool surrounds.
- Replace a portion, e.g. 50%, of the water in each whirlpool and spa pool daily.
- Completely drain whirlpools, spa pools and natural thermal pools and thoroughly physically clean all surfaces and all pipe work regularly.
- Maintain and physically clean heating ventilation air conditioning (HVAC) systems serving the room in which spa pools are located.
- Installation of signs that list standard safety precautions, placed near the recreational water environments that cautions people who are immunocompromised or who are taking immunosuppressant medicines against using the recreational water environments.

Routine cleaning of the whole circulatory system, including the spa, sprays, pumps and pipe work, is critical and can require quite intensive doses of disinfectant since *Legionella* can persist in biofilms (scums on the surfaces of fittings and pipework) making them difficult to inactivate.

Bathers can be encouraged to shower before entering the water. This will remove pollutants such as perspiration, cosmetics and organic debris that can act as a source of nutrients for bacterial growth and as neutralising agents for the oxidizing biocides. Bather density and duration in whirlpools and spa baths can also be controlled. Spa pool facilities may require programmed rest periods during the day to allow recovery of disinfectant concentrations.

Another important risk factor is the system supply air to the spa pool room. Adequate ventilation should reduce risks from *Legionella*, but it is important that the system does not create its own risks. All surfaces of HVAC systems serving the room in which the spa is located should be physically cleaned and disinfected to control biofilm.

Frequent monitoring of control measures will help to provide early warning of deviations and could include:

- checking and adjusting the disinfection residual and pH;
- inspection of maintenance and cleaning operations;
- inspection of the physical condition of recreational water environments, filters and equipment; and
- undertaking surveillance for lower respiratory illness (e.g. pneumonia) among passengers and staff by recording all visits to the ship's medical office for confirmed or suspected pneumonia.

12.6.3 Humidifiers

There is no evidence to date of an outbreak, or case of Legionnaires' disease, on a ship, to be associated with the heating, ventilation air conditioning (HVAC) systems. Air conditioning systems on ships are generally dry and do not have evaporative coolers. However, humidifiers (including food display units) are often installed on ships and could generate aerosols. Special attention should be paid to the proliferation of *Legionella* in humidifiers. Liquid should not be allowed to accumulate within such units, they must drain freely and have easy access for cleaning. It is important to maintain and physically clean HVAC systems.

12.7 Persistent infectious agents

It is not possible to eliminate all risks of an outbreak resulting from persistent infectious agents on ship, but risks can be reduced. To prevent outbreaks education of crew and passengers, such as through notices, signs and pamphlets, is vital since both crew and passengers need to adopt basic control measures to reduce the risks and should always be advised to:

- wash hands with soap and frequently, and always after using toilets and changing nappies and always before handling or consuming food;
- avoid putting fingers in or near the mouth unless first washed;
- avoid placing objects that may have been touched into the mouth;
- limit direct contact with others, even during greetings, such as the shaking of hands and kissing;
- limit indirect contact with others, such as the sharing of drink containers and eating utensils; and

- during and shortly after illness or suspected illness, remain in cabins as much as possible to minimise contact with others nor take part in food handling duties or other duties that may readily lead to transmission of infection.

Passengers or crew that are determined not to become infected should take extra precautions such as avoiding uncooked foods and unbottled water, including ice. Unpackaged foods, such as buffets, where people might well touch the food with hands, or with utensils that have been handled, dropped or put in mouths, or salivated on, should be avoided.

Additional systematic precautions that can be taken by ships include:

- eliminating self-serve eating facilities, or at least supervising these facilities closely and preventing children from using them;

- sanitizing items both between and even during voyages, this can include any environmental surface that might be touched by one infected person and lead to indirect transmission to another (toilet and tap operating handles, eating and drinking utensils, door handles, remote control devices, switches on lights, radios and air conditioning units, chair, table and bedding surfaces and carpets);

- maintaining a watching brief to detect early warning signs of an outbreak (requests for medication, visits to medical staff etc); and

- the earliest possible detection of disease symptoms and management of patients, including isolation.

Additional details on these control measures are given below where they are discussed in a different context.

12.7.1 Controlling an outbreak

An outbreak of infectious gastroenteritis, such as that caused by Norovirus (NV), is often diagnosed presumptively on clinical grounds from characteristic epidemiological features. Outbreaks are often explosive in their onset with projectile vomiting a prominent feature. Attack rates may be as high as 50%. Criteria for suspecting an outbreak include:

- short incubation of 12-48 hr;

- illness duration of 12-60 hr;

- vomiting in > 50% of symptomatic cases; and

- both passengers and crew affected.

When an outbreak is suspected it is imperative to institute additional control measures immediately, without waiting for virological confirmation and without waiting for the results of bacterial cultures. Furthermore, the relevant port and national health authorities should be notified and their assistance sought.

7.3.1 Containment levels at individual cabin level

Symptomatic passengers or crew are best advised to stay in cabin. Prompt cleaning and disinfection of areas contaminated by vomit and faeces should be undertaken (see below). Excretion of virus in faeces begins a few hours before onset of symptoms and can continue for up to 7 weeks with maximum shedding occurring 24 to 72 hours after exposure. Emphasis must be given to cleaning staff and crew regarding handwashing after contact with affected passengers or crew and objects, before handling food or drink and on leaving an affected area or cabin. Cleaning staff would typically wear gloves and aprons. Although there is evidence that airborne transmission is possible, the wearing of masks is generally not essential unless spattering or aerosolisation is anticipated.

7.3.2 Food and water safety

If the characteristic of an outbreak suggests a point source, the relevant control measures need to be re-checked and rigorously enforced and epidemiological investigations should be undertaken to identify or exclude a food or water source.

Since food and waterborne outbreaks have occurred on ships, kitchen hygiene practices and water safety management need to be reviewed and monitored. Outbreaks have been associated with pre-symptomatic, symptomatic and post symptomatic food handlers and viral shedding can occur from asymptomatic, infected individuals. Infected food handlers should be encouraged to report symptoms and be excluded from work until at least 48 hours afters symptoms have ceased. Exposed food that will not be cooked, such as fruit, should be discarded if it may have become contaminated.

7.3.3 Environmental cleaning

Prolonged outbreaks on ships suggest that NVs can be harboured in the ship environment. In one outbreak, illness was associated with sharing bathrooms and having a cabin mate who vomited. The authors concluded that contaminated communal bathrooms and environmental contamination were implicated in the transmission of infection. Subsequent outbreaks were prevented by repeated and thorough bathroom cleaning and rapid cleaning of contaminated rooms. During an outbreak there is a need for a comprehensive and responsive cleaning and disinfection programme during and at the end of an outbreak.

Particular attention can be given to cleaning objects that are frequently handled such as taps, door handles and toilet or bath rails. The timing of the terminal cleaning process should be at least 72 hr post resolution of the last case. This takes into account the period of maximal infectivity (48 hr) plus the typical incubation period (24 hr) for the newly infected individuals. Affected areas should be cleaned and disinfected.

There is no direct evidence to support the use of particular agents for environmental disinfection as there is no viral culture system available for NVs. The related feline calicivirus is inactivated by heat at 60ºC and by hypochlorite at 1000 mg/L (ppm) (0.1%), but not ethanol.

Contaminated linen and bed curtains can be placed carefully into laundry bags appropriate to guidelines for infected linen (such as soluble alginate bags with a colour coded outer bag) without generating further aerosols. Contaminated pillows should be laundered as infected linen unless they are covered with an impermeable cover in which case they can be disinfected with 0.1% hypochlorite solution.

Carpets and soft furnishing are particularly difficult to disinfect. Hypochlorite is not generally recommended as prolonged contact is required and many such items are not bleach resistant. Steam cleaning may be used for carpets and soft furnishings, provided they are heat tolerant (some carpets are "bonded" to the underlying floor with heat sensitive materials). However, this needs to be undertaken thoroughly as a temperature of at least 60ºC is needs to be achieved to be confident that disinfection has been achieved and in practice, tests have shown that such high temperatures are often not reached in carpets during steam cleaning. Vacuum cleaning carpets and buffing floors have the potential to re-circulate NVs and are not recommended.

Contaminated hard surfaces can be washed, such as with detergent and hot water, using disposable cloth, then disinfected with a disinfecting solution, such as 0.1% hypochlorite. Disposable cloths can be disposed of safely, e.g. as clinical waste. Non disposable mop heads and cleaning cloths can be laundered as contaminated linen on a hot wash.

7.3.4 Separation and embarking and disembarking passengers

Embarking and disembarking passengers would typically be separated if possible. If an outbreak has occurred on a ship, embarkment of new passengers can be delayed until the ship environment has been thoroughly cleaned and disinfected as described above.

12.8 Disease vectors

As vectors such as rodents, vermin and flying insects may have access to ships when in port, control measures for the suppression of vermin and insect infestation are necessary. These control measures can be carried out under the direction of a ship's officer charged with this responsibility and frequently inspected.

12.8.1 Insects

One or more of the following control measures may be employed:

- Regular inspection of ship spaces, particularly where infestation is most likely to occur, such as food-storage, food handling and refuse disposal spaces.
- Elimination of pest hiding places and point of accumulation in which trash and debris, food particles, or dirt may accumulate.
- Frequent cleaning of living quarters and spaces where food is stored, prepared, or served or in which dishes and utensils are washed and stored.
- Proper storage and disposal of food refuse and rubbish (see Chapter 5).
- Elimination of habitat for insect larvae ideally through design or, if unavoidable, though maintenance, such as preventing the formation of standing water in lifeboats.
- Use of screens on all structural openings to the outer air during seasons when insects are prevalent.
- The application of suitable insecticides.

Residual and space sprays would typically be used for the control of any flying insects that do invade a ship. Space sprays are released as a fog or fine mist and kill on contact. Residual sprays leave a deposit on surfaces where flying insects rest and where other insects crawl. Crawling insects and vermin are best controlled by specific insecticides, properly applied to the crawling, resting and hiding places. These residues retain their killing power for a considerable period of time.

As spray insecticides may contain substances toxic to man, all surfaces that come in contact with food and all dishes and utensils and food and drink may need to be covered or removed during spraying operations. Insecticides usually are not stored in food spaces and the containers need to be marked, such as wit the word "POISON", and coloured to provide ready identification. Drinking water sources and utensils usually need to be protected from contamination.

Vessels holding water can be screened from insects and inspected frequently to check for, and eliminate, mosquito breeding. Refuse stores can be screened and inspected frequently to check for, and eliminate, the breeding of flies.

Screens need to be kept in good repair. Bed nets, in good repair and properly placed, need to be used in sleeping quarters not provided with screens.

12.8.2 Rodents

The master of the ship can delegate one person, such as the ship's carpenter, to be responsible for the trapping programme. Traps can be set after leaving any port where rats might have come on board either directly from the dock or with cargo or stores. If all traps are still empty after a suitable period, perhaps two days, they can be taken up. If rats are caught, the traps in that area can be rebaited and reset until no more rats are caught. A record of where the traps were set, the dates and results can be entered in the ship's log and a copy available for the port health inspector.

Rodents leave droppings which provide a ready indicator of infestation. Regular inspection of the ship to look for droppings will readily show whether rodents have gained access to the ship. Inspection can focus particularly on spaces where food is stored and prepared and where refuse is collected and disposed of, as well as cargo hold while in port.

Rodents pose a major threat to the safety and suitability of food. Rodent infestations can occur where there are breeding sites and a supply of food. Good hygiene practices should be employed to avoid creating an environment conducive to rodents. Good sanitation, inspection of incoming materials and good monitoring can minimize the likelihood of infestation and thereby limit the need for pesticides.

Most rodenticides are poisonous to man. The containers can be marked with words such as "POISON" and stored away from foodstuffs and food preparation and food storage areas; they can be coloured to prevent accidental use in food preparation. As rodenticides may be very toxic, caution must be used in their application, and instructions for their use carefully followed.

All rat-proofing needs to be kept in good repair and inspected and maintained regularly. Potential harbourages would typically be inspected regularly to check for any signs of rats.

12.8.3 Eradication

Pest infestations would typically be dealt with immediately and without adversely affecting food safety or suitability. Treatment with chemical, physical or biological agents can be carried out without posing a threat to the safety or suitability of food.

12.9 Surveillance

Shipboard surveillance requires consistent and accurate record keeping, data collection, record retention, and routine reporting of illnesses. Accurate records enable ship and public health officials to identify and characterize problems, assist outbreak investigators and to collect pertinent and timely data, and to identify the pathogens and risks associated with illness. The Surgeon can use standard definitions such as:

- Gastrointestinal Illness – three or more episodes of loose stools in 24 hours or vomiting plus one additional constitutional symptom such as headache, muscle aches, abdominal cramps, fever, or bloody stools.

Responsibility for medical record keeping, data collection and record retention will depend on the size and nature of the vessel and crew. Records may be maintained by medical or nursing staff, when available, or by the designated first aid officer. Reporting is the responsibility of the Master.

All ships can maintain health records for crew containing, typically this would be, at minimum, a record of a valid medical certificate and a record of immunizations for each crew member. All ships would typically maintain a medical log for crew members. Logs are useful for noting illness trends and identifying potential outbreaks. Medical logs for at least the previous 12 months can be kept on board ship. At a minimum the information collected in the medical log would typically include the following:

- name of crew member;
- job title;
- age;
- sex;
- nature of illness;
- dates of onset of illness;
- treatment (ship or shore-based);
- date of restriction and resumption of duties; and
- date of death (if applicable).

Often passengers and crew are notified of disease outbreaks by the investigation team. In some instances, such as outbreaks of gastrointestinal illnesses, passengers and crew may be notified prior to the initiation of an investigation so that precautionary measures can be taken. Such notification can be undertaken in consultation with local health authorities.

Reporting of illnesses needs to be done according to the International Health Regulations, local quarantine regulations and the regional regulations of the port of entry. The Master of a vessel or the designated ship official should report, without delay, any deaths to the nearest port. The report would include the cause and circumstances of death, if known.

Illnesses in passengers or crew can be reported to the port of entry (or closest quarantine station, where applicable) at least 24 hours prior to arrival. Illnesses can be reported in accordance with local jurisdiction and government reporting requirements and would typically also be considered in the following situations:

- 2% of the passengers or crew are having the same or similar symptoms;
- 10 or more individuals have the same or similar symptoms;
- the illness is unusually severe;
- the illness is unknown or unexplained; and
- there are deaths attributable to the illness.

13 Port Authority

13.1 Introduction

This Guide recommends a preventative approach to public health protection. A preventative approach requires more than merely responding to outbreaks and occasionally testing end-product materials. Proactive health protection needs to be promoted though rigorous inspection and audit of the preventative control measures to check that they are adequate and that they are functioning as intended. This chapter describes activities that port health officers, national or local health authorities or other competent authorities as so delegated, can consider auditing to promote preventative public health protection and to maintain adequate standards and reputation.

The ship's master or their representative needs to ensure the identification of health risks and the control of these risks. The role of the port health officer is to audit the systems put in place by the ship's master, to verify the practical implementation of these systems, and to provide advice and assistance in improving these systems. In practice the auditing role may need to be separated from the role of determining the adequacy of systems.

An inspection provides a snapshot of the ship's operations and of how systems are implemented and maintained. The officer would typically examine and verify a sample of the risk assessment, the control measures and any associated monitoring. Port health officers would typically seek to identify risks arising from the activities on ships and the effectiveness of the ship's own assessment of risks and control. Both the quality of any plans and the extent of implementation need to be assessed.

13.2 Purpose of the inspection

The inspection is designed to confirm that the ship is operating in accordance with the appropriate practice for assessment and control of health risks. Specifically, the inspection would determine whether the ship's owner/operator has identified relevant hazards, assessed risks and identified suitable controls to effectively manage health risks. Inspections should, therefore, include an assessment of the ship's HACCP plans for food safety and the other public health protection plans in place such as water safety plans. The practical implementation of the plans needs to be assessed.

Before commencing the inspection the officer would typically ensure that the ship's master or their representative have an awareness of the purpose of the inspection. An inspection would normally include a preliminary discussion with the ship's master or representative on matters relating to sanitation systems and procedures as well as a review of the relevant documentation such the risk management plans, WSPs, HACCP plans etc. Visual or physical examination can be used to confirm that control measures have been correctly identified and that controls are in place in practice. Unforeseen potential hazards identified through this assessment can be discussed with the ship's master or their representative during or at the conclusion of the visit and confirmed in writing thereafter.

Preliminary discussions might include consideration of previous inspection reports, consideration of relevant current documentation and identification of all food and water related activities undertaken on the vessel. The main purpose of the subsequent visual or physical examination would be to confirm that control points have been correctly identified and that controls are in place.

On completion of the inspection/audit the officer can again discuss with the ship's master or representative, a summary of the matters which, in the opinion of the officer, do not comply with this Guide and give advice on relevant aspects including an expected timescale for any corrective action.

Where the risk assessment and management system is not satisfactory or evidence of implementation is inadequate, the port health officer may need to carry out a fuller visual and physical examination of the ship. On completion of the inspection the officer can discuss with the ship's master or representative a summary of the matters which, in the opinion of the officer, are not satisfactory against appropriate practice as compared to the level expected for a ship of the type being inspected.

It is important that the process be a positive one for the crew and operators of the ship being inspected and, therefore, the assessment would typically be accompanied by constructive recommendations for remedial action.

13.3 Inspection of specific aspects of the ship

The general principles of inspection and audit can be applied to all aspects of ship safety (e.g. BS EN ISO 19011:2002). In general, the inspection needs to check that risks have been properly assessed, that adequate control measures have been identified and that the controls are being implemented operationally in practice. Port health inspection needs to include audits, sanitary inspections and review of laboratory test results.

There are two types of surveillance that need to be undertaken:

- Indirect assessment involving audit-based approaches whereby the ship's own system for risk assessment and monitoring is examined in terms of what is documented and how this translates into practice including field checking and sanitary inspection.

- Direct assessment in which monitoring and analysis is undertaken directly by the port including aspects such as sampling and analysis.

In general, audit-based approaches are applied to all systems and may be sufficient for large passenger ships with their own management systems in place. Additional, direct assessments may be required for smaller cargo ships with potentially less rigorous systems of their own.

Ports need to maintain access to a readily deployable and stable source of expertise and capacity in order to:

- review health risk assessment and management plans which may be developed by port suppliers, ship owners and ship masters;

- undertake or oversee auditing of the implementation of individual plans as part of a programmed activity;

- undertake any direct inspection, if required; and

- respond, investigate and provide advice on receipt of report on significant incidents.

Periodic audit of the implementation of risk assessment and management plans will be required:

- at regular intervals (the frequency of routine audits will be dependent on factors such as size of ship and quality of facilities);
- following substantial changes to systems or operations; and
- following significant incidents.

Periodic audit can include the following elements:

- examination of records to ensure that operational activities are being carried out as described in the plans;
- checking that the operational monitoring parameters are kept within specification and that compliance is being maintained or corrective actions followed through;
- review of any changes in plans including the improvement and updating process; and
- inspection of the physical systems in place on ship and at the port.

In response to reports of significant incidents, port inspectors would typically check that:

- the cause of the incident was investigated promptly and appropriately;
- the cause of the incident was determined and resolved;
- the incident and corrective action was documented and reported to the appropriate authorities; and
- the relevant risk management plan was modified to avoid a similar recurrences.

13.3.1 Assessing the identification of hazards and risks

When an inspector reviews the risk assessment, it can be useful to categorise hazards as being microbial, chemical or physical. A further categorisation of hazards can involve looking at their origin:

- inherent - a hazard which is likely to be present at the outset;
- contamination - a hazard arising by contamination at a particular point in the supply chain;
- multiplication - a hazard may increase (e.g. microbiological growth or toxin production) at a particular point in the supply chain; and
- survival - a hazard might survive a particular point designed to destroy it.

In some instances, hazards may be identified but the actual risks will be minimal and control will be unnecessary. Port health officers can give priority to those hazards that pose the greatest risk to safety. Port health officers can seek evidence to substantiate any judgement that a risk is or is not acceptable. The issues which may need to be considered by officers when assessing risks may include:

- What knowledge and experience of the hazard exists - have problems occurred on similar ships?
- What is the severity/seriousness of the hazard?
- What is the risk to health and the benefit of controlling the hazard?
- Is the risk imminent?
- Will the risk increase over time if not controlled?
- How many people will be exposed to the hazard?
- What is the age/vulnerability of those exposed to the hazard?
- What will be the degree of exposure to the hazard for an individual?

13.3.2 Assessing control measures

Once the risk assessment has been reviewed and therefore, the hazards that require control have been identified, officers can consider the adequacy of existing controls. Many hazards can be controlled by a variety of means. Port health officers would not recommend or enforce controls that are unnecessary or excessive. The issues which can be considered by officers when assessing existing controls may include:

- Is the ship operating controls to recognized industry benchmarks or legal standards, where applicable?
- What controls and related monitoring and records are already in place?
- Do existing controls make the risk acceptable?
- If not, can the controls be easily modified are substantial changes/new controls necessary?
- Is there a later stage in the operations that will adequately and reliably control the risk?
- Is it possible to reduce the risk to acceptable levels and can appropriate controls be applied?
- Can the risk be reduced to acceptable levels by allowing passengers/crew to control their own exposure?
- What are the consequences of no control?
- What is the sanitation record of the ship?

Port health officers are seeking to identify deficiencies that demonstrate risks will not be adequately controlled by existing systems in order to justify changes. The issues to be considered by officers when identifying options for necessary controls may include:

- What range of suitable control options is available?

- What is the most suitable and practical control for the particular operation?
- Wan low cost controls significantly reduce the risk as effectively as high cost ones?
- Is there an industry norm that appears to work effectively?
- Do the public health benefits outweigh the costs?

Port health officers would need to have regard to what is reasonable and practicable. Officers assessing control options would typically consider technical availability and reasonable costs. Equally, ship owners and masters need to recognise that there will be cases where risks are unacceptable and must be controlled at any cost.

Where a hazard cannot reasonably be eliminated then controls need to be identified that will reduce the risk so that it becomes acceptable. Achieving zero risk is not possible although officers can seek to ensure that controls are in place so that risks are at tolerable levels.

It is the responsibility of the ship owner/operator to control any risks. Nevertheless, inspecting officers need to be willing to give reasonable assistance in identifying suitable and relevant control options.

Water Safety

The WHO provides guidance to water safety which recommends that a Water Safety Plan (WSP) be implemented (see Chapter 2). If it exists, such a plan can provide the framework against which to audit water safety on ship. If a direct assessment is required, this can examine the following components:

- sanitary inspection of the ship water supply system (loading, storage, distribution, disinfection, filtration, production);
- sampling to be carried out by suitably qualified personnel; and
- tests to be conducted using suitable methods by accredited laboratories.

Surveillance testing should always include water quality indicators (e.g. *E coli*, chlorine residuals). However, it may be appropriate in some circumstances to examine water for a range of other parameters (e.g. chemical contaminants).

Food Safety

The WHO recommends the development of Food Safety Plans (FSP) incorporating the HACCP principles (see Chapter 3). Analogous to the case for water, if such a plan exists it can provide the framework against which to audit food safety on ship.

13.4 Water Safety

A port authority needs to ensure the availability of a sufficient quantity of appropriate quality water. A port may receive potable water from either a municipal or private supply and 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. Water boats and barges are equipped to receive and provide water for both potable and non potable water systems aboard ships under conditions where direct shore delivery is not practicable. These boats have water tanks, water hoses and hose fittings, pumps and independent pipe systems to provide potable water. Designated filling hoses would typically be provided at each pier or wharf for the use of ships not provided with these designated filling hoses. Typically, one smaller hose would be provided for smaller ships and two larger hoses for larger ships, as well as two larger hoses at each pier or wharf. The hose would typically be around 15 m (50 ft) in length.

13.4.1 Transfer of water from shore to ship.

Water to be used for potable water purposes aboard ships needs to be provided with sanitary safeguards from the shore source, through the shore water distribution system, including connections to the ship system, and through the ship system at each outlet in order to prevent contamination or pollution of the water during ship operation.

Ships can have two or three water systems, for example: potable, non-potable and water for the fire system. Whenever practicable, only one water system would be installed to supply potable water for drinking, culinary purposes, dish washing, hospital and laundry purposes. Non potable water, if used on the ship, would be loaded through separate piping using fittings incompatible for potable water loading. This water would flow through a completely different piping system and be identified with a different colour.

13.4.2 Watering facilities at the port

Potable water for ships, including water-boats and water-barges, needs to be obtained only from those water sources and water supplies that provide potable water of a quality in line with the standards recommended in WHO Guidelines for Drinking-water Quality (WHO 2004), especially in relation to bacteriological requirements and chemical and physical requirements. Potable water would typically need to be obtained from those watering points approved by the health administration or health authority.

Facilities include piping, hydrants, hoses and any other equipment necessary for the delivery of water from shore sources at the pier or wharf area to the filling line for the ship’s potable water system. Plans for the construction or replacement of facilities for loading potable water aboard vessels would typically be submitted to the port health authority or other designated authority for review. Plans would typically show the location and size of the distribution lines at pier or wharf area, location and type of check valves or other back flow preventers, location and type of hydrants, including details of protection of outlets and storage facilities for the protection of filling hoses and attachments. New or repaired facilities would typically be disinfected before the facility is put into or returned to service.

The lines’ capacity would need to be such as to maintain positive pressure at all times to reduce the risk of backflow. The lines are usually to be located above normal high water level in the harbour to reduce the risk of seawater inflow. There would typically be no connections between the potable water system and other piping systems. Backflow of contaminated water into the potable water system needs to be prevented by proper installation of piping and plumbing.

All fittings, meters and other appurtenances used in connection with the loading of potable water only need to be handled and stored in a sanitary manner. Inlets and outlets of potable-water meters would typically be capped when not in use.

Hydrants need to be adequately and continuously covered and located so that they do not receive discharge from the waste of a ship.

Hoses represent a weak point in the water supply chain. They need to be designed exclusively for the delivery of potable water and have unique fittings for potable water. They would typically be properly labelled or tagged so that they are not used for any other purpose. Potable water hose lockers would typically be constructed of smooth, non-toxic, corrosion resistant material and should be maintained in good repair. Such lockers can be marked with words such as "POTABLE WATER HOSE AND FITTINGS STORAGE" and be self-draining.

13.4.3 Water boats and barges

Water boats and water barges are vessels especially constructed and equipped to receive and provide water for both potable and non potable water systems aboard ships under conditions where direct shore delivery is not practicable. These craft need to be equipped with potable water tanks, water hose and hose fittings, pumps and independent pipe systems to provide potable water only to potable water systems on ships. The reception, handling, storage and delivery to ship water systems needs to be carried out under completely sanitary conditions. Facilities for disinfection, when and where necessary on board, need to be available. Plans for the construction of these craft would typically show filling lines, storage tanks, pumping equipment and protective measures for approval by the port health authority or other designated authority.

13.4.4 Treatment

If water is suspected of being contaminated by microbial pathogens, filtration capable of removing micron size particles can provide a first barrier. The intensity of treatment would depend on the degree of contamination of the source water. Filters may be used in the loading line prior to disinfection. Filters need to be accessible for inspection and removable for cleaning. Filters need to be properly maintained, cleaned and reinstalled to ensure proper operation.

Disinfection following filtration would provide the second barrier. Disinfection is most efficient when the water has already been treated to remove turbidity and when substances exerting a disinfectant demand, or capable of protecting pathogens from disinfection, have been removed as far as possible. However, disinfection does not always eliminate all infectious agents. For example, low residual disinfectant is easily overcome by gross contamination. Furthermore, parasites such as *Cryptosporidium* are very resistant to chlorine disinfection and need to be removed by filtration or inactivated by an alternative disinfectant such as UV irradiation.

13.4.5 Residual disinfection

In some extended distribution systems a residual disinfectant is required to be maintained to protect from growth of microbial hazards that can impart off flavours to the water and foul lines and fittings. If temperatures are in the range of approximately 25 to 50ºC for prolonged periods then pathogens may be able to grow in the water too and either a good residual needs to be maintained or the temperature needs to be controlled to be continually above or below this range.

13.4.6 Source water risk management

Water supplied to ships, including water boats and barges, would normally be only from those water sources and supplies that provide water of a quality in line with the standards recommended in the WHO Guidelines for Drinking-water Quality.

Watering points at ports may need to be approved by the Port Health Authority or other designated authority. The ship's master or officer responsible for the loading of water would typically ascertain whether or not the source of the water is potable.

Examples of source water hazards, control measures, monitoring and corrective actions is given in Table 2-2.

Table 3-2. Examples of source hazardous events, control measures, monitoring procedures and corrective actions.

Hazard/ Hazardous events	Control measure	Monitoring procedures	Corrective action
Contaminated source water	Routine checks on source water quality	Monitor turbidity and microbial indicators	Filtration and disinfection or use alternative source
Defective filters	Routine inspections and maintenance Regular backwashing and cleaning of filters	Monitor filter performance using turbidity	Repair or replace defective filters.
Contaminated hoses	Regular cleaning and disinfection Regular repair and maintenance Proper storage and labelling	Routine inspections	Repair or replacement Cleaning and disinfection
Contaminated hydrants	Regular cleaning and disinfection Regular repair and maintenance	Routine inspections	Repair or replacement Cleaning and disinfection
Cross connections with non potable water at loading	Correct design and plumbing Correct labelling. No connection with non potable water	Routine inspections	Install new plumbing Isolate part of system Rechlorination, flush
Defective backflow preventers at loading	No defects that allow ingress of contaminated water	Routine inspections, repair and maintenance	Repair or replace

14 Port Health Authority

14.1 Introduction

If an outbreak is suspected it is important to seek to contain the outbreak and investigate its cause. Ideally, the investigation and control of disease outbreaks on ships would be a multi-disciplinary task making use of skills in the areas of clinical medicine, epidemiology, laboratory diagnostics, environmental health and ship design and operations. In practice, even if not all of these skills are readily available, all efforts should be made to investigate and control any outbreaks to the fullest extent possible. This chapter focuses on the practical aspects of outbreak investigation and control but also provides generic guidance that can be adapted to individual countries and local requirements.

14.2 Planning and preparation

Under the International Health Regulations (IHR) the generic core competencies and protocols for investigating, responding to and reporting public health emergencies are described in the IHR. The responsibilities for the investigation and the management of outbreaks will vary between countries and depend on the nature and size of the outbreak, its importance with regard to the health of passengers and crew and other factors.

To investigate and control outbreaks successfully it is necessary to work rapidly and responsibly. Therefore, clear systems and protocols need to be in place, developed in advance, so that when an outbreak occurs all persons involved in the investigation can be clear on their course of action time is not lost with matters such as policy discussions. Therefore, the responsible port and ship authorities - in consultation with all agencies that may be involved in the investigation – would typically develop outbreak investigation and control plans to address:

- The arrangements for consultation and informing the authorities at local, national and international level. For example, list the specific authorities that need to be contacted at ports en route along with their contact details.
- The precise roles and responsibilities of organizations and individuals involved. For example, identify the role that crew play in notifying cases of illness and determine who should contact port health authorities.
- The resources/facilities available to investigate outbreaks. For example, identify how disease cases will be detected early.
- The details of an outbreak control team. For example, identify when to convene the outbreak control team, its composition and its duties.

14.3 Detection of outbreaks

Surveillance is required to detect an outbreak. It is important for all ships to keep logs of suspected illness complaints from passengers or crew and to actively monitor any confirmed cases of illness to look for an outbreak in progress. General definitions of outbreaks are:

- two or more linked cases of the same illness or an increase in the number of observed cases over the expected cases;

- an incident in which two or more persons experience the same illness after exposure to a common source, which caused, or is thought to have caused, the illness; and
- for botulism or chemical poisoning one case will constitute an outbreak.

Other specific definitions include:

- Foodborne disease: any disease of an infectious or toxic nature caused by, or thought to be caused by, the consumption of food.
- Waterborne disease: any disease of an infectious or toxic nature caused by, or thought to be caused by ingestion of contaminated water or ice or from contact (bathing, swimming, inhalation, ocular exposure) with etiologic agents in water.

14.4 Investigation of outbreaks

The overall objectives for investigating disease outbreaks are:

- to control ongoing outbreaks:
    - o to detect and separate the implicated source from passengers and crew;
    - o to identify specific risk factors related to the host, the agent and the ship;
    - o to determine factors that contributed to contamination, survival and growth of the suspected agent; and
- to prevent future outbreaks.

A full investigation of an outbreak on a ship will normally include:

- epidemiological investigations;
- environmental investigations; and
- laboratory investigations.

14.4.1 Outbreak control team

The criteria for convening an outbreak control team (OCT) will include consideration of the seriousness of the illness, available resources, attack rate and if any high risk populations, such as infants or elderly people, are affected. If the ship is in or near the port, the port health authority in the area which first identified and reported the outbreak would initiate proceedings to set up an OCT. Alternatively, an OCT might be formed on ship. Those constituting an OCT will vary according to circumstances but might include:

- aboard ship:
    - o ship's engineer;
    - o ship's restaurant manager;

    - the ship's doctor and other clinical staff; and
    - secretarial support.
- at port, as aboard ship plus:
    - a public health practitioner or epidemiologist under the authority of the Public Health Officer in charge;
    - an environmental health officer; and
    - a microbiologist;

In addition, a specialist professional may be needed to support the OCT in some situations according to the presumed nature of the outbreak, possibly including:

- a water engineer;
- a virologist; and
- a toxicologist.

The role of the OCT is to co-ordinate all activities that are conducted to investigate and control an outbreak. This activity may involve all or some of the following tasks:

- aaoard ship:
    - inspection of ship including galleys, water systems and recreational water facilities;
    - determining if there is really an outbreak;
    - agreeing and implementing control measures to prevent the further spread by means of exclusions, withdrawal of contaminated foods, treatment of contaminated water etc;
    - determining what type of investigations are to be conducted;
    - case finding and interviews; and
    - planning the appropriate clinical and environmental sampling;
- at port, as above plus:
    - considering detaining the ship;
    - making arrangements for media liaison; and
    - producing a report, including lessons learned.

14.4.2 Record keeping

From the beginning of a suspected outbreak it is essential to ensure that all information received and all decisions taken by the OCT and others is recorded reliably and with the appropriate level of confidentiality. This includes that:

- individual members of the OCT keep personal daily logs;
- all OCT meetings are formally minuted and distributed; and
- action notes are distributed immediately after OCT meetings .

14.4.3 Communication

An important aspect of successful outbreak management is effective communication. Throughout the course of an outbreak it is important to share relevant information between those on the OCT as well as to third parties. Key stakeholders usually involved in outbreak management include:

- port health authorities/port authorities;
- water companies;
- the ship's doctor;
- the ship's master;
- the passengers and crew; and
- the media.

14.5 Epidemiological investigations

The investigation of a potential outbreak on a ship starts with the assessment of all available information to confirm or refute the existence of an outbreak and to establish a working diagnosis. The assessment has to be initiated quickly, should be completed within a matter of hours. The objective is to collect information to help the investigator decide whether there is an outbreak and what it may be caused by and include:

- checking the validity of the information;
- identifying cases and obtaining information from them; and
- ensuring the collection of appropriate clinical and environmental samples.

Once the validity of the reporting source has been checked some of the initial cases (e.g. 5-10) would typically be identified and interviewed as soon as possible. This will help to better understand the clinical features to see which persons are affected and to gather additional critical information. The interviews should be wide ranging and open ended and include as a minimum questions about:

- clinical details, date of onset, duration and severity;
- contact with other ill persons;
- risk factor exposure history (food, water, recreational water environments, other persons);

- what the cases think caused their illness;
- if they know others with similar illness; and
- if they have anything in common with those who have the same illness.

Laboratory confirmation of the aetiological agent from initial cases is useful to guide further investigations. Some pathogens and poisonous chemicals are detectable in the patient for only for a short period after the onset of illness. Therefore, clinical specimens (e.g. faecal samples, vomitus) from the cases would typically be collected at the time of the initial contact or soon afterwards. If a case or other exposed person has leftover samples of what may have caused the illness, such as suspected foods that were eaten in the 72 hours before the onset of illness, these can be taken for laboratory examination. However, it's important to note that if the contamination could have been transient, the absence of contamination in a sample of a suspect matrix does not necessarily mean that the matrix was not contaminated at the time. For example, water contamination might have been of relatively short duration and by the time symptoms appear the contamination might have passed.

The ship and its systems would typically be inspected with particular attention being given to assessing the proper operation of important control measures. This might include temperature of storage of foodstuffs, cross-contamination controls for food and water, residual disinfectant in water and water treatment system performance. Appropriate food, water and environmental samples can be collected for laboratory analysis. If the vehicle of infection is thought to be food or water, the galley, food areas or water supply points on the ship would typically be inspected and sampled as early as possible as the amount of physical evidence that may have caused the outbreak will diminish with time.

14.5.1 Form preliminary hypotheses

From the initial information garnered from laboratory analysis, ship inspection and interviews with the passengers and crew it is often possible to form preliminary hypotheses about the cause of the outbreak and the degree of risk to the passengers and crew. General control measures and precautionary measures may be implemented at this stage. For instance suspect foods can be removed from the galley, water can be disinfected, pools can be closed, infected food handlers can be excluded from work and infected persons can be asked to remain in their cabins. These obvious control measures need not be delayed because the investigation is still underway. Furthermore, any samples collected can be stored to enable subsequent analysis.

At the end of this preliminary phase a decision is needed whether or not to continue with the investigation. In some cases it may be apparent that the outbreak is clearly over or that there is no continuing risk to passengers or crew. If a decision is made to discontinue the investigation, the reasons for the decision would typically be carefully documented. On the other hand, if the source or the aetiology of the outbreak is unknown, investigations would continue to identify them. Other reasons to continue the outbreak might include:

- if there is a high level of passenger or crew concern;
- if litigation is likely to result from the outbreak; and
- if an investigation would generate new knowledge.

14.5.2 Descriptive epidemiological investigations

Most outbreaks of disease warrant at least a descriptive study so that information captured can be used to prevent similar outbreaks. Descriptive epidemiology provides a picture of the outbreak by the three standard epidemiological parameters: time, place, and person. A descriptive study allows development of a more specific hypothesis about the source and mode of transmission and may suggest the need to collect further clinical, food, water or environmental samples or to carry out further studies. The steps of descriptive epidemiology are to:

- establish a case definition;
- identify cases and obtain information from them;
- analyse the data by time, place, and person characteristics;
- determine who is at risk of becoming ill;
- form hypotheses about the exposure/ vehicle that caused the disease;
- compare hypotheses with established facts; and
- decide if more systematic studies (e.g. analytical studies) are needed to test the hypotheses.

14.5.3 Analytical epidemiological investigations

Analytical studies introduce a comparison group which allows the strength of the relationship between an exposure and the disease under investigation to be assessed. The two most commonly used types of analytical studies in outbreak investigations are cohort studies and case-control studies. The case-control study is the most relevant to ship outbreak investigation and involves a retrospective comparison of the exposures of those with the disease, i.e. the cases, with the exposures of those that do not have the disease, i.e. the controls. On the other hand the cohort is prospective in that both exposed and non-exposed groups are monitored over time to enable comparison of disease rates during the time covered. In both cases statistical techniques are applied to calculate the strength of association between the exposure and disease symptoms relative to absence of disease.

14.6 Environmental investigations

Environmental investigations are conducted to find out why an outbreak occurred to enable preventative action to avoid similar occurrences in the future. The specific objectives of an environmental investigation are:

- to identify the source, mode and extent of the contamination;
- to assess the likelihood that pathogens or toxins survived processes designed to remove them or reduce their concentration or to prevent their transfer; and
- to assess the likelihood that pathogens or toxins grew or arose due to growth or recontamination during handling and storage.

Environmental investigations will differ according to the nature and size of the outbreak, the type of ship and the number of passengers and crew. Because the amount of physical evidence will quickly diminish with time, environmental investigations should be carried out as soon as possible and samples need to be collected as early as possible and then stored until analysis takes place.

Traditionally, investigation methods have focused on visual inspection and end product testing for suspected disease vectors. With the advent of preventative risk management systems such as hazard analysis critical control point (HACCP) and water safety plans (WSP), greater emphasis is now given to monitoring of control processes. In contemporary outbreak investigations both methods, end product sampling and inspection of process performance, are combined.

14.6.1 Inspection of the ship

As well as assessing specific procedures related to a suspect source, the overall structure and operational hygiene of the ship can be inspected. In most cases the inspection will take place prior to the results of epidemiological or laboratory investigations being available. However, if there is information, the inspection would be guided by what is already known about the outbreak. If a source has been identified as probable epidemiologically, the investigation would focus on why this particular source became contaminated. If laboratory investigations identified a particular pathogen or toxin, the investigation would focus on those sources and conditions known to be associated with that hazard. Environmental investigations are more rapid and are of greater value if they have a clear focus.

To investigate the role of a suspect food requires knowledge of its complete processing and preparation history, including sources and ingredients, crew who handled the items, procedures and equipment used, potential sources of contamination, and time temperature conditions to which food were exposed. Investigation of galleys and food areas on ships will usually require:

- an inspection of the overall structural and operational hygiene arrangements;
- a specific assessment of procedures that a suspect food underwent; and
- food and environmental sampling.

To investigate a role of suspect water requires knowledge of its complete history throughout the water supply chain - source of water, procedures at port to treat water, procedures at port to load water, backflow prevention at loading, storage conditions, treatment and residual disinfectant used on board the ship, backflow prevention devices on the ship, any repair works or cross connection, frequency of maintenance and cleaning of storage tanks, training of crew and so forth. Investigation of the water systems will usually require:

- an inspection of the structure including water tanks and pipes;
- a specific assessment of any water treatment e.g. filtration, disinfection
- water sampling;
- disinfection residual testing; and
- assessment of procedures to monitor backflow preventers.

14.6.2 Sample collection

The purpose of collecting environmental samples is to trace the sources and the extent of contamination that led to an outbreak. Samples may be taken from suspect transmission routes such as fomites, waste disposal systems, food materials, water, pools, air, working surfaces, equipment and containers. In addition, samples should include relevant clinical specimens from crew and passengers these can include faecal samples and nasal, subungueal and skin swabs. It is important to ensure the appropriate methods for collection, preservation and shipment of specimens is adopted. Pre-determined, documented sampling procedures would ideally be in place and the necessary sampling equipment should be available to appropriately trained crew. Key sampling requirements include:

- clean, sterile sample containers with caps;
- clean, sterile swabs and sample collection tools;
- quenching and sample preserving agents; and
- a refrigerated sample storage area for labile samples.

Samples should ideally be taken as early as possible as the amount of physical evidence will diminish with time. However, many of these samples will be stored with only those most relevant being analysed. It is more efficient to apply a targeted analysis of those samples most likely to identify the causative agent. Examples of appropriate material for samples are:

- left over foods or water from a suspect consumption event;
- water from recreational water environments or cooling systems;
- sources known to be associated with the hazard in question; and
- source where practices or situations may have permitted the survival or growth of suspect microorganisms.

If there is no material left from the suspected source of exposure, samples of items that would be expected to be as similar as possible should be collected. For example, raw materials might be available and should also be sampled. Storage areas can be checked for items that may have been overlooked and garbage or waste management systems may contain discarded material. Any supplier names and code identification information can be recorded to allow assessment of distribution channels if needed. Ice can provide a convenient sample of water that might have been collected earlier.

14.6.3 Laboratory investigations

Most outbreaks of disease are microbial in origin and their investigation will usually require a microbiology laboratory. However, symptoms of both chemical and microbial outbreaks can be similar and difficult to distinguish so both chemical and microbial analysis is likely to be required initially.

Diagnosis of most clinical diseases can only be confirmed if the aetiological agent is isolated and identified from ill persons. This is more important when the clinical diagnosis is difficult because signs and symptoms are very nonspecific as is the case with many diseases. Faecal samples are the most commonly collected specimens. Other specimens include vomitus, urine, blood and clinical specimens such as swabs from nostrils, skin or nasopharynx.

Laboratory samples should ideally be taken from ill persons as soon as possible. In large outbreaks, specimens would typically be obtained from at least 10-20 individuals (ideally 15-20% of all cases) who manifest illness typical of the outbreak and from some exposed, but not ill, persons. Once the diagnosis has been confirmed there is not normally any need to obtain additional samples if individuals manifest characteristic symptoms.

Specimens would be collected from persons who have presented with illness and ideally those persons would be interviewed to establish their possible exposures. A unique identifier on the laboratory request form and the questionnaire would allow linking laboratory results with epidemiological information.

All containers would be labelled with a waterproof-marking pen before or immediately after collection with the patient's name, identification, date, time of collection and other necessary information. The nature of the specimens and whether it is from a case or from a person without symptoms would typically be stated on the laboratory request form.

Microbial sampling and analysis

If pathogens are to be tested for, specialist clinical advice and specialist analytical facilities are likely to be required to determine what to test for and to undertake the test respectively. However, as a general rule, if cases are presenting with diseases that may have arisen from faecal contamination then faecal indicators, such as *E. coli*, should be tested for in environmental samples. In addition, specific pathogens can be tested for in environmental samples. However, it is often difficult to detect pathogens in environmental samples (although indicators such as *E. coli* are more readily detected if present). Therefore, in most cases analysis of clinical samples will be used to identify the probable causal agent of a disease outbreak rather than environmental samples.

It is important to note that when pathogenic bacteria or faecal indicators are isolated from samples, their presence alone may be insufficient to support a presumptive association. Some faecal organisms are common enough in the environment (e.g. *E. coli* and some *Salmonella* spp) that their presence in related specimens may be coincidental. Typing of isolates can be useful to compare isolates from clinical samples and environmental samples and results may show pathogens to be distinct and therefore unrelated, or still indistinguishable, thus increasing the significance of their isolation. Equally, the absence of pathogens or faecal indicators in a sample does not prove that a particular matrix was not that cause. Contamination might be sporadic and sampling may have missed the contamination event, or the method used for analysis may have sought the wrong pathogen or not been sufficiently sensitive to detect contamination.

Chemical sampling and analysis

If chemical intoxication is suspected, the specific chemicals that are to be tested for is likely to be determined based on clinical advice and specialist analytical facilities who would advise what to test for and to undertake the test respectively. In acute chemical exposures most toxins or their metabolites are rapidly cleared from easily accessible specimens such as blood. Therefore prompt collection and shipment of specimens is of critical importance. When collecting samples for chemical analyses it is important to closely collaborate with the analytical laboratory, make arrangements in advance for chemical samples to be analysed and to seek advice about what specimens should be collected and how. Because cross contamination must be ruled out, blank material may be provided by the laboratory to ensure that extraneous contamination has been controlled for.

The types of specimen to be collected will depend on the suspected chemicals, for example, if organic or inorganic substances are involved. In case of an emergency where it is not possible to contact the laboratory, biological specimens (whole blood, serum, urine, and vomitus) and environmental samples should be collected as soon as possible, sealed in a clean container and sent to the laboratory quickly.

14.7 Control measures

The primary goal of an outbreak investigation is to control ongoing disease and to prevent future outbreaks. At best, control measures are guided by the results of these investigations. However, this may delay the prevention of further cases and it is unacceptable from a public health perspective to await conclusive findings before acting. On the other hand, some interventions, such as detaining a ship, can have serious economic and legal consequences and would ideally be based on the best available information. Thus, timely implementation of appropriate control measures requires maintaining a delicate balance between the responsibility to prevent further disease and the need to protect the credibility of the ship or passenger shipping industry. Control measures can be implemented to:

- control the source;
- control transmission; and
- protect risk groups.

14.7.1 Control of source

Once the investigations have identified a suspect source associated with transmission of the suspected pathogen, measures can be taken to control these sources. Steps may include

- removing implicated substances from the ship and informing the supplier from where the items was purchased;
- emptying stocks of material (such as pool or drinking water, foodstuffs), thoroughly cleaning the containment and then refilling from a safe source;
- treating contaminated substances or remedying defects; and
- modifying processes once environmental investigations identify faults.

14.7.2 Control of transmission

The risk of spreading infection by infected persons depends on their clinical picture and their standards of hygiene. Persons with diarrhoea present a far greater risk of spreading infection than asymptomatic persons with subclinical illness spread. In some cases, patients can be asked to remain in their cabins to avoid spreading diseases that can be transmitted by direct person-to-person spread via air and fomites. No person should handle unpackaged food - even if clinically well - if having any of the following conditions:

- excretors of *Salmonella typhi* or *Salmonella paratyphi*;
- excretors of the aetiological agents of cholera, amoebic dysentery or bacillary dysentery;
- hepatitis A or hepatitis E and all other forms of acute hepatitis until diagnosed to be hepatitis A or hepatitis E;
- *Taenia solium* (pork tapeworm) infection; and
- tuberculosis (in the infectious state).

More broadly, it is important to consider the risks that might arise from international disease transmission. For example, if a ship is carrying passengers or crew that are carrying a communicable disease, it's possible that the ship will not be able to board at some ports, or may need to be detained in port, to curtail outbreak transmission.

14.8 End of outbreak

The OCT at some point would formally decide when an outbreak is over and issue a statement to this effect. An interim report would typically be made available by the OCT within 2 to 4 weeks after the end of the investigations followed by a written final report. The report would typically follow the usual scientific format of an outbreak investigation report and include a statement about the effectiveness of the investigation, the control measures taken and recommendations for the future to avoid similar events. By formally presenting recommendations, the report provides a record of the event to assist others in preventing and responding to similar events in future as well as representing a record of performance to assist with any legal matters.

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