

3 Foodborne Disease

3.1 Health concerns

Significant levels of foodborne disease transmission on ships has 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 nearer 50%. 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.

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

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 or water”. This definition includes all food and waterborne illness regardless of the presenting symptoms and signs: it thus includes not only acute illnesses characterized by diarrhoea and/or vomiting, but also illnesses presenting with manifestations not related to the gastrointestinal tract, such as scombrotxin 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.

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

Foodborne biological hazards 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.

The level of contamination can be minimized by adequate control of handling and sound storage practices (hygiene, temperature and time). Furthermore, most of the organisms of concern are killed or inactivated by properly conducted normal cooking processes.

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 makes contamination by the unclean hands of infected food handlers or cross-contamination from human faecal contamination the prime risk factors.

A range of helminthic and protozoan parasites can contaminate food. Many are zoonotic and can infect a range of animals leading to direct contamination of the food. 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.

Chemical contaminants in food may be naturally occurring or may be added during the processing of food. Examples of naturally occurring chemicals are mycotoxins (e.g. aflatoxin), scombrototoxin (histamine), ciguatera toxin, 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 was not identified.

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

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

3.2 Standards relating to food safety on ship

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

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). The CAC guidance provides important information on basic food safety which will be referred to throughout this chapter.

3.3 Construction

Adequate well-constructed and well-lit facilities are required for the safe preparation, handling, serving and storage of food and beverages. Equipment and facilities should 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 in intended use and, where necessary, suitably durable, and easy to maintain and clean;
- Where appropriate, suitable facilities are available for temperature, humidity and other controls; and
- There is effective protection against pest access and harbourage

3.4 Design and layout

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

In particular the following specific conditions should be satisfied where necessary to protect the safety and suitability of food:

- The surfaces of walls and partitions should be made of impervious materials with no toxic effect in intended use;
- Walls and partitions should have a smooth surface up to a height appropriate to the operation;
- The decks or flooring of all spaces should be constructed to allow adequate drainage and cleaning. The bottoms of shaft wells in these spaces should be so constructed and maintained as to permit ready access for cleaning;

- Bulkheads and deckheads should 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, should be insulated if condensation forms or is likely to form;
- Drainage lines carrying sewage or other liquid waste should not pass directly overhead or horizontally through spaces for the preparation, serving, or storage of food, or the washing of utensils;
- Deck drains should be provided in all spaces where flooding -type cleaning is practised or where water or liquid is discharged in to the deck. They should be provided with water-seal traps, except where drainage is directly overboard. Drains from refrigerated spaces should be protected against backflow;
- Windows should be easy to clean, be constructed to minimize the build up of dirt and where necessary, be fitted with removable and clearable insect proof screens;
- Doors should have smooth , non absorbent surfaces, and be easy to clean and, where necessary, disinfect; and
- Working surfaces that come into direct contact with food should be in sound condition, durable and easy to clean and maintain and disinfect. They should be made of smooth, non-absorbent materials, and insert to the food, to detergent and disinfectants under normal operating conditions.

3.5 Equipment and utensils

Equipment and containers coming into contact with food should be 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 should be made of materials with no toxic effect in intended use. Where necessary, equipment should 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 should 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 suitability of food. Equipment used to cook, heat, treat, cool, store or freeze food should be designed to achieve the required food temperatures as rapidly as necessary in the interests of food safety. Such equipment should be designed to allow temperatures to be monitored and controlled.

Containers for waste, by products and inedible or dangerous substances, should be specifically identifiable, suitably constructed and where appropriate, made of impervious material.

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 should be so

constructed as to be easily cleaned and should be kept clean and in good repair.

3.6 Facilities

3.6.1 Water

An adequate supply of potable water with appropriate facilities for its storage and distribution should be available whenever necessary to ensure the safety and suitability of food. Two outbreaks of *Vibrio parahaemolyticus* gastrointestinal illness occurred on two ships in 1974 and 1975. These outbreaks were associated with use of seawater in the galley. The implicated seafoods were probably contaminated after cooking or thawing in seawater from the ship's internal seawater distribution systems. In each outbreak the seafoods were mishandled and left at ambient temperature for hours, and when refrigerated, were left in large buckets that would not cool properly. 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. Non-potable water (e.g. seawater) should have a separate system and should not be supplied to the galley. The management of the reticulated potable water on ship is discussed under Chapter 2.

3.6.2 Cleaning and disinfecting

Adequate facilities should be provided for cleaning food, utensils and equipment. Such facilities should have an adequate supply of hot and cold potable water. Personnel hygiene facilities should be available to ensure that an appropriate degree of personal hygiene can be maintained and to avoid contaminating food. Some outbreaks on board ships were associated with lack of hygienic facilities near the galley. In an outbreak of multiple antibiotic resistant *Shigella flexneri* 4a the spread of the 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.

Facilities to be located beside the galley should include:

- Adequate means of hygienically washing and drying hands, including wash basins and a supply of hot and cold water;
- Lavatories of appropriate hygienic design; and
- Adequate changing facilities for personnel.

3.6.3 Ventilation

Adequate means of natural or mechanical ventilation should be provided. Ventilation systems should 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 should be readily removable for cleaning. Particular attention should be given to:

- Minimise air-borne contamination of food, for example, from aerosols and condensation droplets;

- Control ambient temperatures; and
- Control humidity, where necessary, to ensure the safety and suitability of foods.

3.6.4 Lighting

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

3.6.5 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.

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 should be provided. Adequate facilities for the storage of food, ingredients and non-food chemicals (e.g. cleaning materials, lubricants, and fuels) should be provided. Food storage facilities should 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).

3.7 Operational Management

3.7.1 Sources of food

All food must be obtained from shore sources approved or considered satisfactory by the health administration. Food should be clean, wholesome, free from spoilage and adulteration, and otherwise safe for human consumption. Raw materials and ingredients should 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 should be identified and applied. Stocks of raw materials and ingredients should be subject to effective stock rotation.

3.7.2 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 should 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 should be checked at regular intervals and tested for accuracy.

Food should 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

All refrigerators should be so constructed that they can be readily cleaned. They must be kept clean and in good repair. Sufficient shelving should be provided in all refrigeration units to prevent stacking and to permit adequate ventilation and cleaning.

Recommended temperatures for perishable food storage are as follows:

- Food to be held hot should be placed in a hot-holding apparatus already at a temperature of at least 62.8°C (145°F) and maintained at that temperature until required;
- All perishable food or drink should be kept at or below 4°C (40°F) except during preparation or when held for immediate serving after preparation. When such foods are to be stored for extended periods, a temperature of 4°C (40°F) is recommended. Fruits and vegetables should be stored in cool rooms. Ideally, meat and fish should be maintained at 0 - 3°C (32-37°F), milk and milk products at 4°C (40°F) and fruit and vegetables at 7-10°C (45-50°F); and
- Frozen foods should be kept below -12°C (10°F).

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 should 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, should 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 should be thoroughly cleaned and where necessary disinfected after raw food, particularly after meat and poultry, has been handled.

Systems should 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.

3.7.3 Maintenance and sanitation

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

Cleaning should 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 should 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 should 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 should specify:

- Areas, items of equipment and utensil to be cleaned;
- Responsibility for particular tasks;
- Methods and frequency of cleaning; and
- Monitoring arrangements.

3.7.4 Personal hygiene

Crew 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 should 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, should be covered by suitable waterproof dressings.

Personnel should always 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, where appropriate.

People engaged in food handling activities should 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 should 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, should not be allowed to enter any food handling areas if there is likelihood of their contaminating food. Any person so affected should 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.

Conditions which should be reported to management so that may 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.

3.7.5 Training

Those engaged in food preparation or who come directly or indirectly into contact with food should 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 should be aware of their role and responsibility in protecting food from contamination or deterioration. Food handlers should have the necessary knowledge and skills to enable them to handle food hygienically. Those who handle strong cleaning chemicals or other potentially hazardous chemicals should be instructed in safe handling techniques.

Periodic assessments of the effectiveness of training and instruction programmes should be made, as well as routine supervision and checks to ensure that procedures are being carried out effectively.

Managers and supervisors of food processes should 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.

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.

3.8 Food Safety Plans and the control of food hazards

Food poisoning on board vessels can be reduced by 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;

- Cross-contamination control, both direct and indirect;
- 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. Seawater should not be used near food or food preparation areas; and
- 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.

The above should be supported by the implementation of a 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 (1997) 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.

3.8.1 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 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.

3.8.1.1 Prerequisite supporting programs

The prerequisite supporting programs of a FSP have been discussed already in this chapter. They 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.

3.8.1.2 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.

3.8.1.3 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.

3.9 References

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