Modern Environmental Science and Engineering (ISSN 2333-2581)
October 2018, Volume 4, No. 10, pp. 897-910
Doi: 10.15341/mese(2333-2581)/10.04.2018/001
Academic Star Publishing Company, 2018
www.academicstar.us

Study on Risk Prevention of Food Plant Buildings and Facilities in Japan

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Abstract: The objective of this study is to review crucial points for risk prevention of buildings and facilities of Japanese food plants where the system of Hazard Analysis and Critical Control Point (HACCP) is applied to the hygiene management. For this purpose, the author investigated several food plants which exercised hygiene management on the basis of the HACCP system, by arranging interviews with relevant industries and inspecting their production manuals. In this paper, the HACCP system practiced in food plants is discussed and the investigation carried out for this study is outlined, where three food plants including a soy sauce manufacturer are picked up to examine their flow planning of such elements as raw materials/packaging materials, waste materials, wastewater, people and air.

Key words: food, plant, risk, risk prevention, quality, flow line

1. Introduction

The food environment has changed significantly in recent years in Japan, due to the development of manufacturing technologies and increasing quantities of food imports. Also, as the number of incidents related to food safety increases, the need for risk management of food plant buildings and facilities has been emphasized.

The objective of this study is to review crucial points for risk prevention of food plant buildings and facilities where the HACCP system is applied to the hygiene management. For this purpose, the author investigated several food plants which exercised hygiene management on the basis of the HACCP system, by arranging interviews with relevant industries and inspecting their production manuals.

In this paper, the origin and characteristics of the HACCP system practiced in food plants are summarized and the investigation carried out for this study is outlined, where three food plants including a soy sauce manufacturer are picked up to examine their flow planning and essential features.

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2. Hygiene Management in Food Plants

2.1 HACCP System

2.1.1 History of the HACCP System

The HACCP system is a hygiene management system established by Dr. Bauman et al. at Pillsbury Company in the US for production and quality control of space foods, and then officially publicized in 1971. This system attracted worldwide attention, and the International Commission on Microbiological Specifications for Foods (ICMSF) issued the report on HACCP jointly with the World Health Organization (WHO) in 1980, and advised HWO in 1988 to integrate the HACCP into the International Standard. In 1993, the Codex Alimentarius Commission (CAC), which is a joint intergovernmental body of the Food and Agriculture Organization of the United Nations (FAO) and WHO, set guidelines for the implementation of the

HACCP system, and the HACCP principles started to be adopted rapidly by many countries.

2.1.2 Characteristics of the HACCP System

The HACCP system is a hygiene management method of performing Hazard Analysis (HA) and finding Critical Control Point (CCP) in food production. Unlike the conventional methods which put emphasis on the inspection of final products, this system aims to secure safety of products by forecasting and preventing any hazards possibly occurring throughout the entire work process from selection and processing of raw materials to production, storage and distribution of final products.

With the introduction of this system, not only food safety but also social credibility of businesses is expected to enhance. Particularly, the monitoring and archiving as part of the hygiene management under the system will allow a given manufacturer to claim the accountability for its products. In addition, under the HACCP system, manufacturers are able to aptly respond to administrative supervision/guidance and customer complaints.

2.2 Hygiene Management in Food Plants

What must be prevented foremost while exercising the food hygiene management is to disappoint customers' trust with food poisoning. To prevent the occurrence of food poisoning, it is crucial to eradicate microorganisms contained in foods as much as possible. In order to do so, foods must be processed at a high temperature before contained and packaged in a clean space.

According to the classification in the Code of Hygiene Practices stipulated by the Ministry of Health, Labour and Welfare (MHLW), the cleanest space is termed a clean work zone, which however is not necessarily required to reach the degree of cleanness the clean room has. In this regard, it can be said that most food plants are operated duly in sanitary space which is nearly equivalent to a clean room, but not so strictly as a clean room dust control is exercised.

2.3 Indicators of Cleanness in Food Plants

Items to be evaluated as indicators of cleanness in fool plants are listed in Table 1. Among all, bacteria and true fungi including molds are particularly important. Table 2 indicates the reference values of bacteria and true fungi. These criteria are not legally binding, but they were found effective in the course of the investigation outlined in Section 2. Those criteria are among indicators for flow planning in designing an ordinary food plant.

Dairy products, for example, are eaten uncooked on many occasions, which tend to cause food poisoning. Thus, not a few plants manufacture such products with the greatest care by converting a packaging room and a filling machine area into a clean room. Operations carried on in a clean room offer an advantage in making the freshness of products kept for long even though food additives including antiseptics are reduced.

The highly sanitary manufacturing area second to the clean work zone is a semi-clean work zone, where production processes of cooking and heating foods and measuring raw materials are handled. Generally, a clean room is rarely set up in a semi-clean work zone.

Table 1 Environmental indicators for food plants.

Items	Measuring instruments/methods of measurement
(1) Bacteria/true fungi	Falling bacteria Airborne bacteria: RCS air sampler Adhesive bacteria: swab test and stamp method
(2) Concentration of suspended particulate matters	Laser light scattering particle counter
(3) Temperature	Copper-constantan thermocouple and recorder
(4) Relative temperature	Capacitive hygrometer and recorder
(5) Pressure (difference)	Differential transformer
(6) Wind speed	Thermister anemometer
(7) Airflow distribution	Tin tetrachloride and smoke tester

Table 2 Cleanness criteria for each work zone in a food plant.

Work zones	Bacteria	True fungi
Clean work zone	Less than 30	Less than 10
Semi-clean work zone	Less than 50	
Dirty work zone	Less than 100	

A less sanitary area is called a dirty work zone, where raw materials and packages are stored; pretreatments like cutting and washing raw materials are conducted; and products are packaged. A dirty work zone will never be built with a clean room, and its construction/facility specifications are drawn up to make it insect-proof and dust-proof.

3. Outline of Investigation in This Study

In this study, the results of follow-up surveys of three different food plants regarding flow lines and clean zones are sorted out, on the basis of interviews with the Japan Food Hygiene Association, the Food Hygiene Management Center, relevant industries, and the federation of industrial cooperative associations in addition to the production manuals provided by 29 manufacturers.

4. Flow Lines in Major Food Plant Buildings/Facilities

As stated above in Section 2, three types of thoroughly traceable manufacturers are focused on in this paper. They are soy sauce, tomato juice and Worcester sauce manufacturers. Characteristics of each plant and important points in flow planning are examined on the basis of the interviews regarding the HACCP system and the production manuals provided by relevant manufacturers.

4.1 Flow Planning in the Cases of Soy Sauce, Tomato Juice and Worcester Sauce Plants

In this section, the flow planning of soy sauce, tomato juice and Worcester sauce plants is examined individually.

4.1.1 Soy Sauce Plant

An example of flow planning in the soy sauce plant is shown in Fig. 1 and its manufacturing process flow in Fig. 2. From Figs. 1 and 2, the characteristics of flow planning in the soy sauce plant are described blow.

(1) It is typical of a soy sauce plant to be structured with separate buildings, where the flow lines of people in and out of each space are created at various stages in the process of manufacture.

(2) As for the flow of products, the manufacturing process is distinctively divided into several stages and each operation is performed in a separate building. Further, an apparatus for producing malted rice, which is indispensable for the fermentation process in the soy sauce plant, is placed across the exterior space so that the rice malt won't affect any other place.

4.1.2 Tomato Juice Plant

An example of flow planning in the tomato juice plant is shown in Fig. 3 and its manufacturing process flow in Fig. 4. From Figs. 3 and 4, the characteristics of flow planning in the tomato juice plant are described blow.

(1) As a characteristic of the tomato juice plant from the viewpoint of people movement, it is observed that the major flow line extends along one walkway. To enter from the walkway into the clean work zones, operators must pass through the front room.

(2) As for the flow planning of products, the production process is made to move from the dirty work zone to the semi-clean work zone and then to the clean work zone. The semi-clean work zone is always placed in between.

4.1.3 Worcester Sauce Plant

An example of flow planning in the Worcester sauce plant is shown in Fig. 5 and its manufacturing process flow in Fig. 6.

From Figs. 5 and 6, the characteristics of flow planning in the Worcester sauce plant are described blow.

(1) The Worcester sauce plant, from the viewpoint of the flow of people, is characterized by the major flow line extending along one walkway in the same way as the tomato juice plant. Further, as the plant is zoned into work sections, the flow of people is efficiently performed.

(2) As for the flow planning of products, the dirty work zone, the semi-clean work zone and the clean work zone are efficiently placed in this Worcester

sauce plant. The operational efficiency is assumed to increase by linking all the relevant sections together.

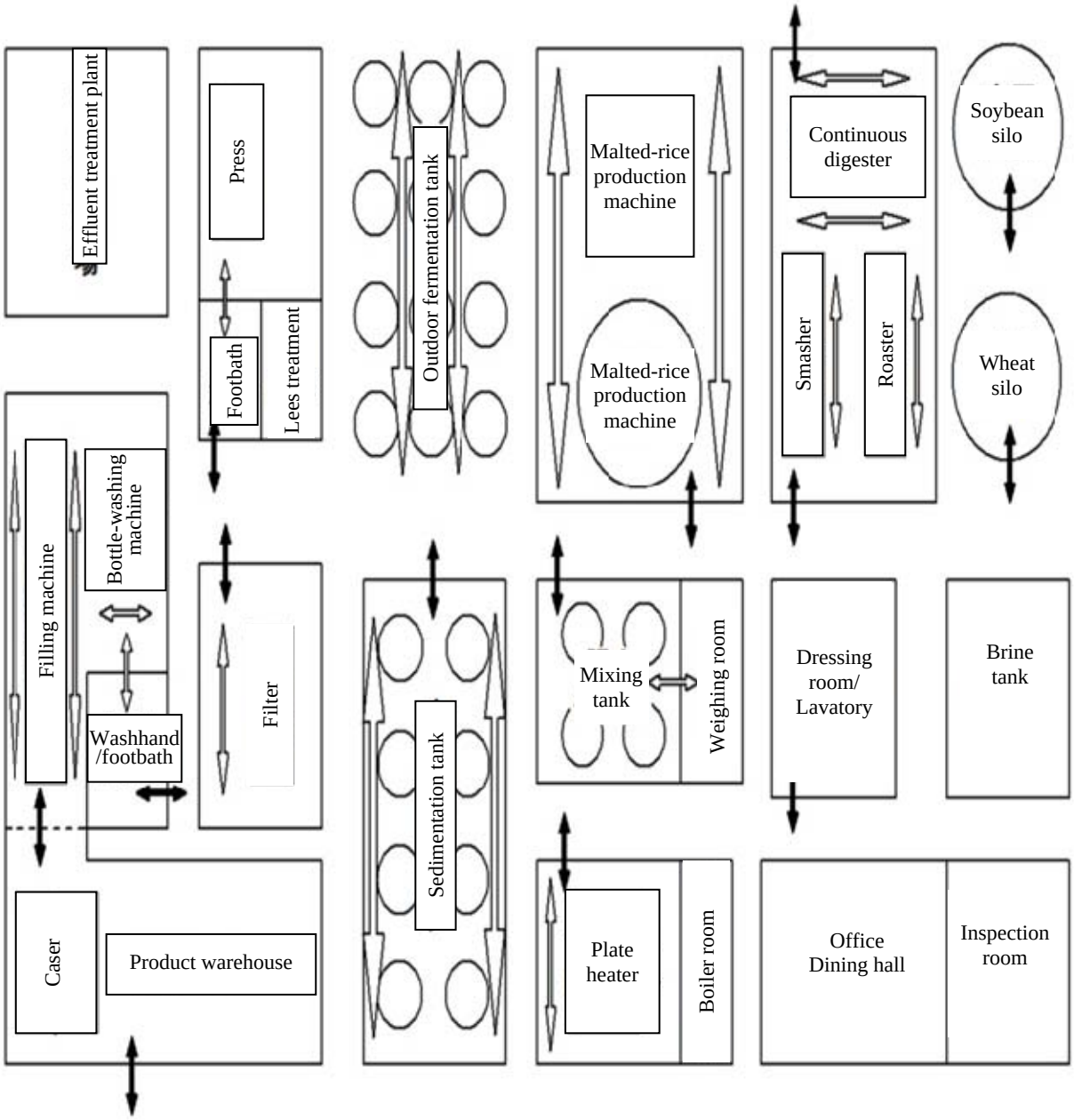

Fig. 1 Flow line of people in the soy sauce plant (flow line of employees).

5. Important Points in Flow Planning for Risk Prevention

In this section, important points in flow planning for risk prevention are sorted out, on the basis of interviews with the Japan Food Hygiene Association, the Food Hygiene Management Center, relevant engineering societies, and the federation of industrial cooperative associations in addition to the production manuals provided by 29 manufacturers.

When flow planning is conceived for a plant, various elements such as raw materials, people and air must be taken into consideration. The performance and value of the entire plant may enhance if the flow lines are planned in such a way that each element is moved most efficiently. In the case of food plants, raw materials are

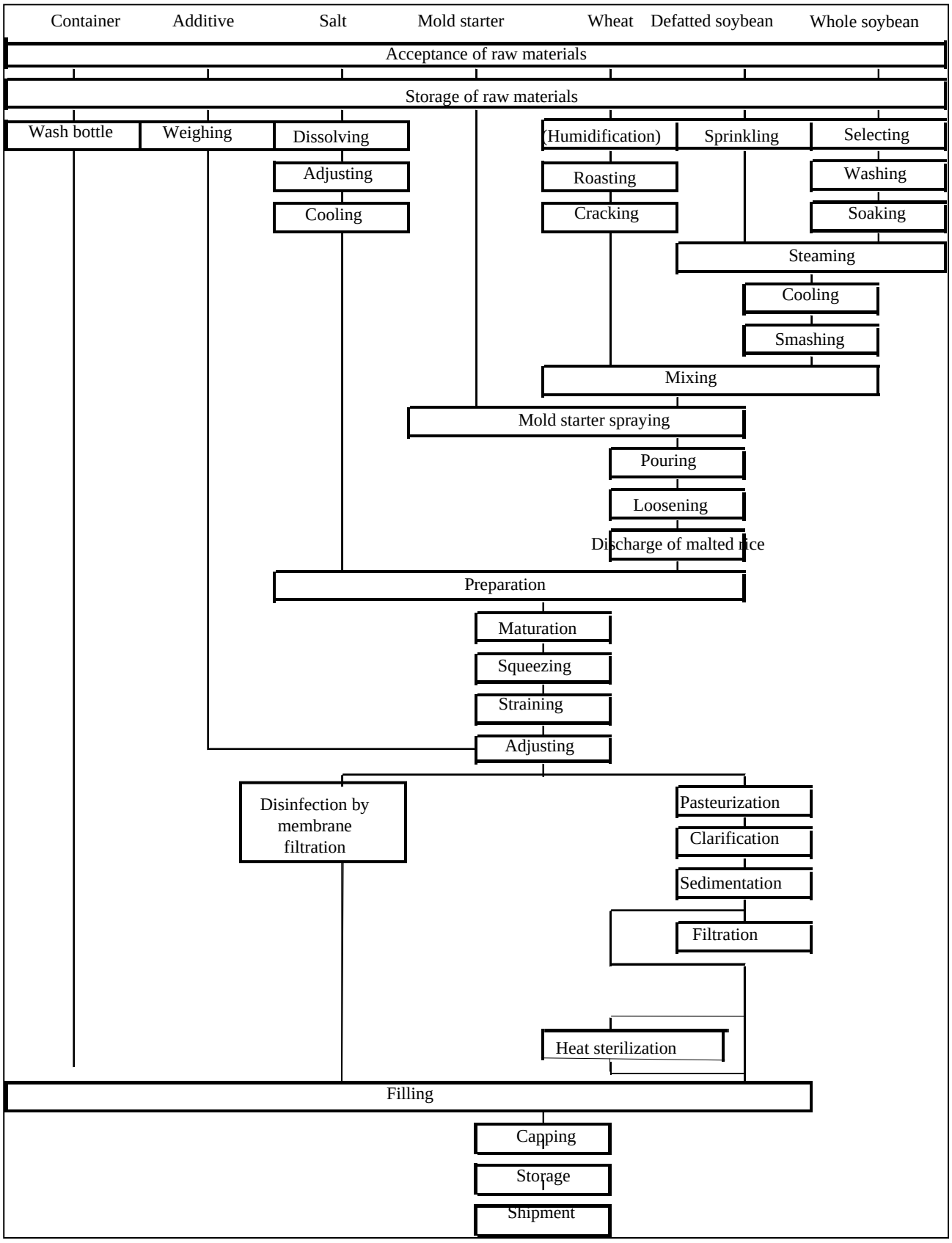

Fig. 2 Manufacturing process flow in the soy sauce plant.

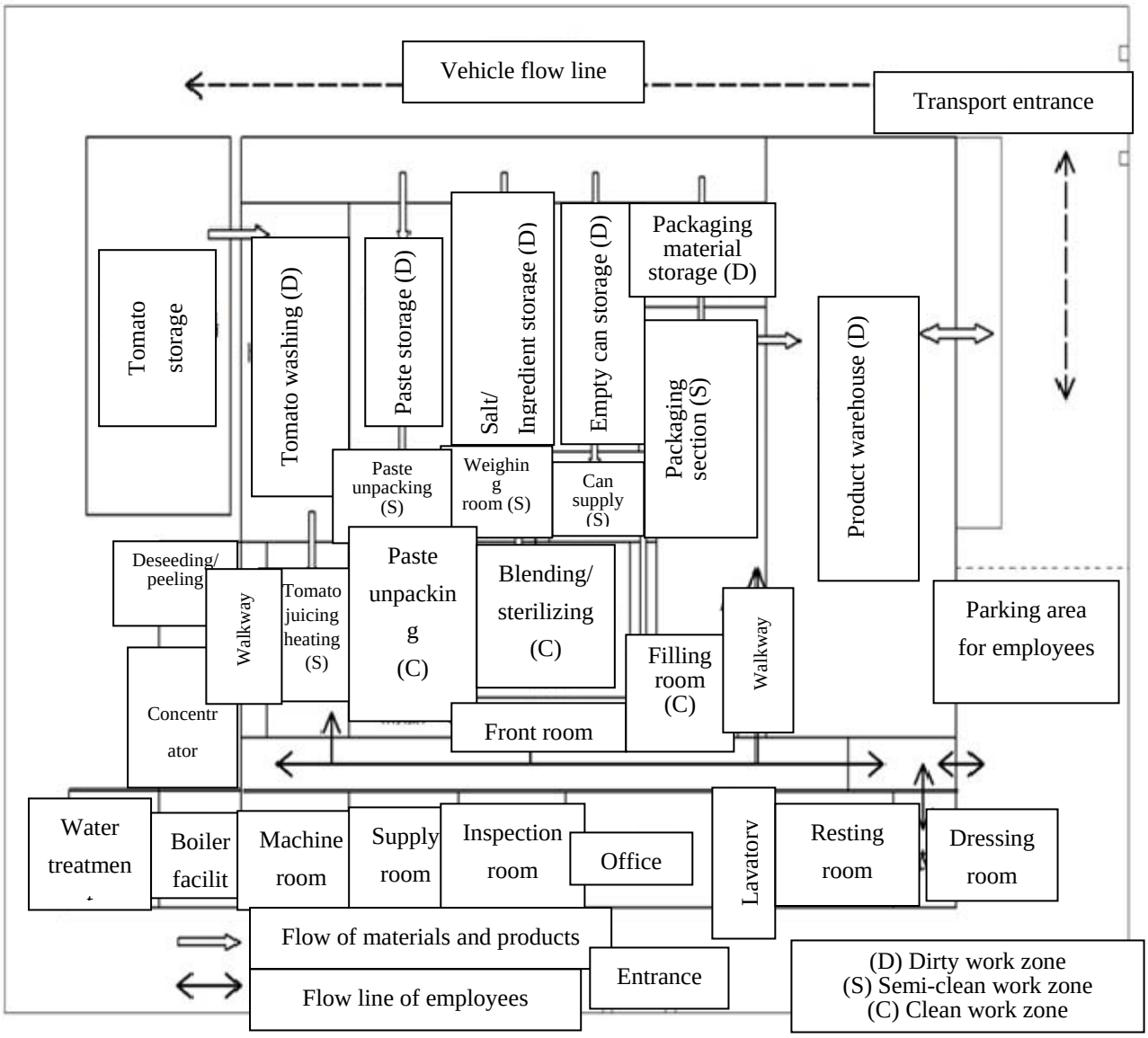

Fig. 3 Flow line of people in the tomato juice plant.

processed into final products and finally packaged for shipping. This process is done not within a single work section but passed through several fields. One of common features with production manuals of most plants including those in this study is that doorways are placed to allow operators direct access to each work zone as they move from place to place in the process of manufacture.

While a zoning plan is newly designed, the number of partitions and doors tends to increase, where the common interest is how to handle those doors. It is known that a door knob touched by many unspecified people can be a source of contamination. Some plants are equipped with devices for opening and closing a door with the help of a foot pedal. In other plants, the food flow line is designed to forward products unidirectionally from start to end.

5.1 Coordination of Flow Planning

On the basis of the flow planning of the soy sauce, tomato juice and Worcester sauce plants examined in Section 3.1, four aspects in the coordination of flow planning to efficiently maintain hygiene are mentioned below.

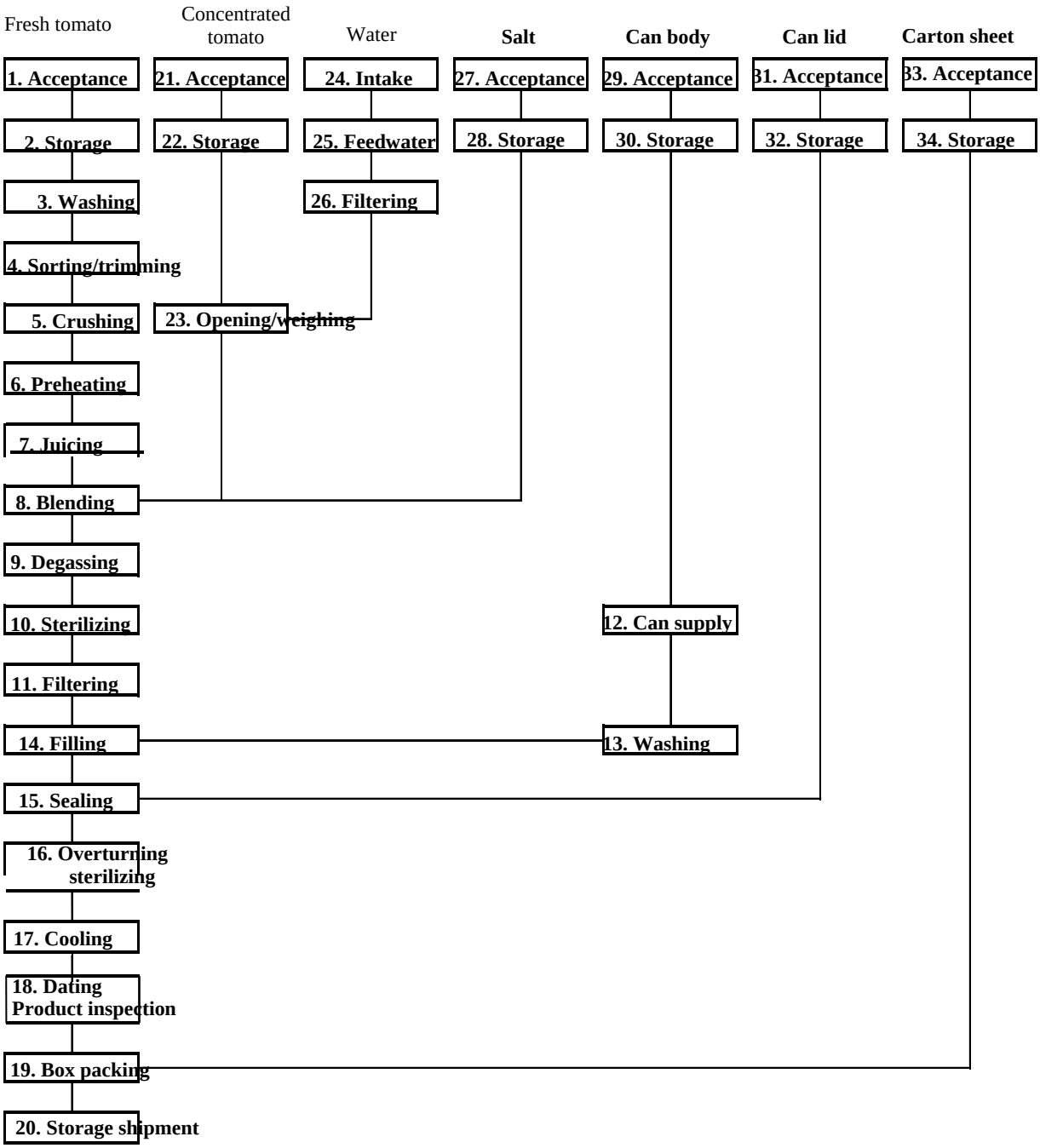

Fig. 4 Manufacturing process flow of the tomato juice plant

(1) Types of Operators

Visitors in general, office management, logistics sector (i.e. receipt and shipment of goods), production sector (i.e., material handling, processing, and filling/packaging), quality control, engineering, outsourcing (i.e., cleaning, material carrying-in, and machinery maintenance), and etc.

(2) Work times

Checking time at the start of operation, regular operation hours, lunch time, recess, cleaning time at the

end of operation, inspection time on a nonbusiness day, repair work, and etc.

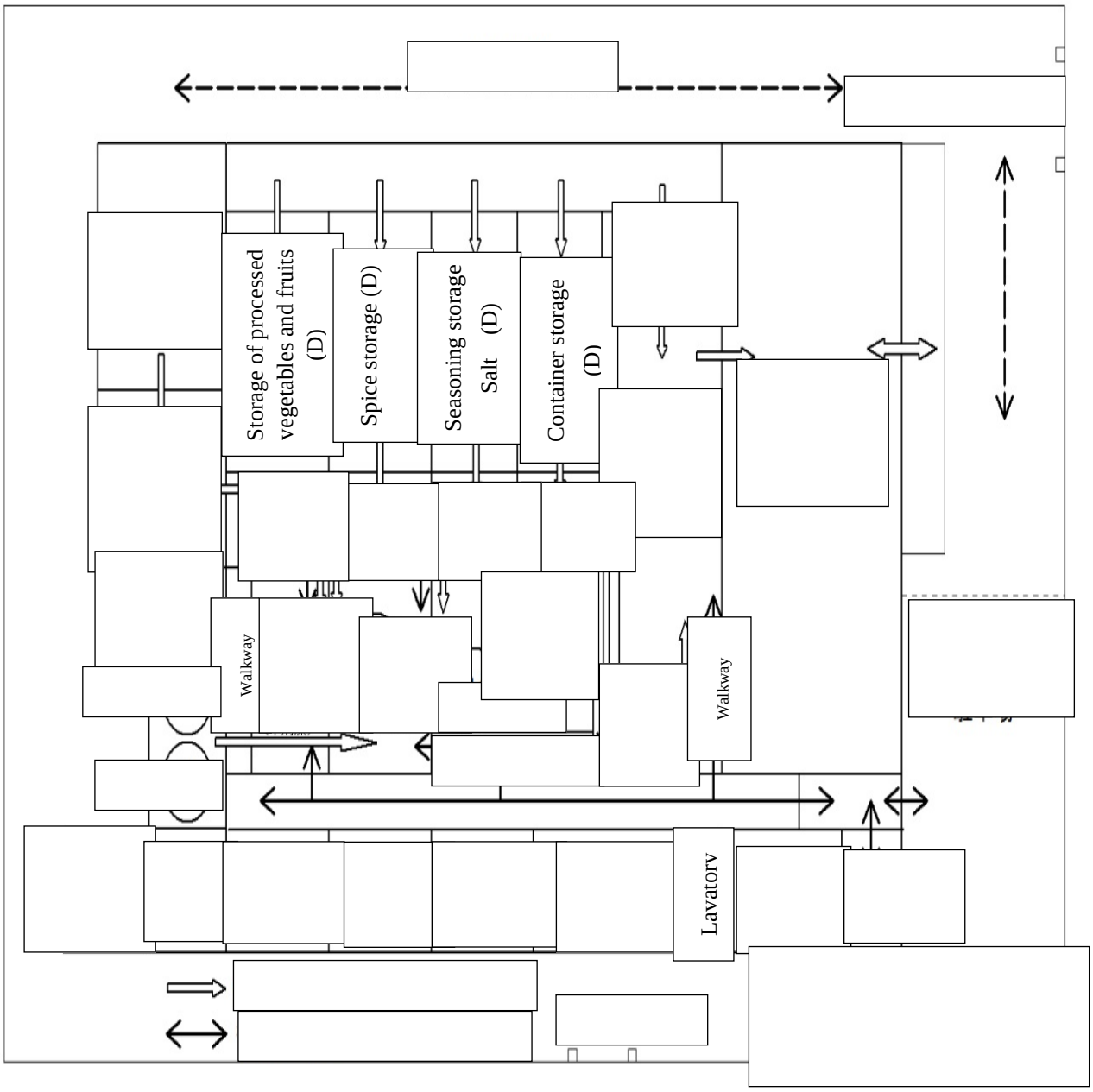

Fig. 5 Flow line of people in the Worcester sauce plant.

(3) Types of materials and products

Raw materials, secondary materials, packaging materials, containers, semi-manufactured goods, quality control test samples, finished products, waste materials, rejected products, and etc.

(4) Other factors

Other influential factors to be examined in flow planning include: air (i.e., outdoor air, conditioned air, and exhaust air), water (i.e., service water and wastewater), steam, compressed air, and etc. Particularly, air contamination is a risk source for products which are made by using air. To draw up flow planning for a food plant, the formation of operations and the zoning are closely related. In this regard, flow planning should be coordinated together with zoning while the manufacturing process flow is surely grasped

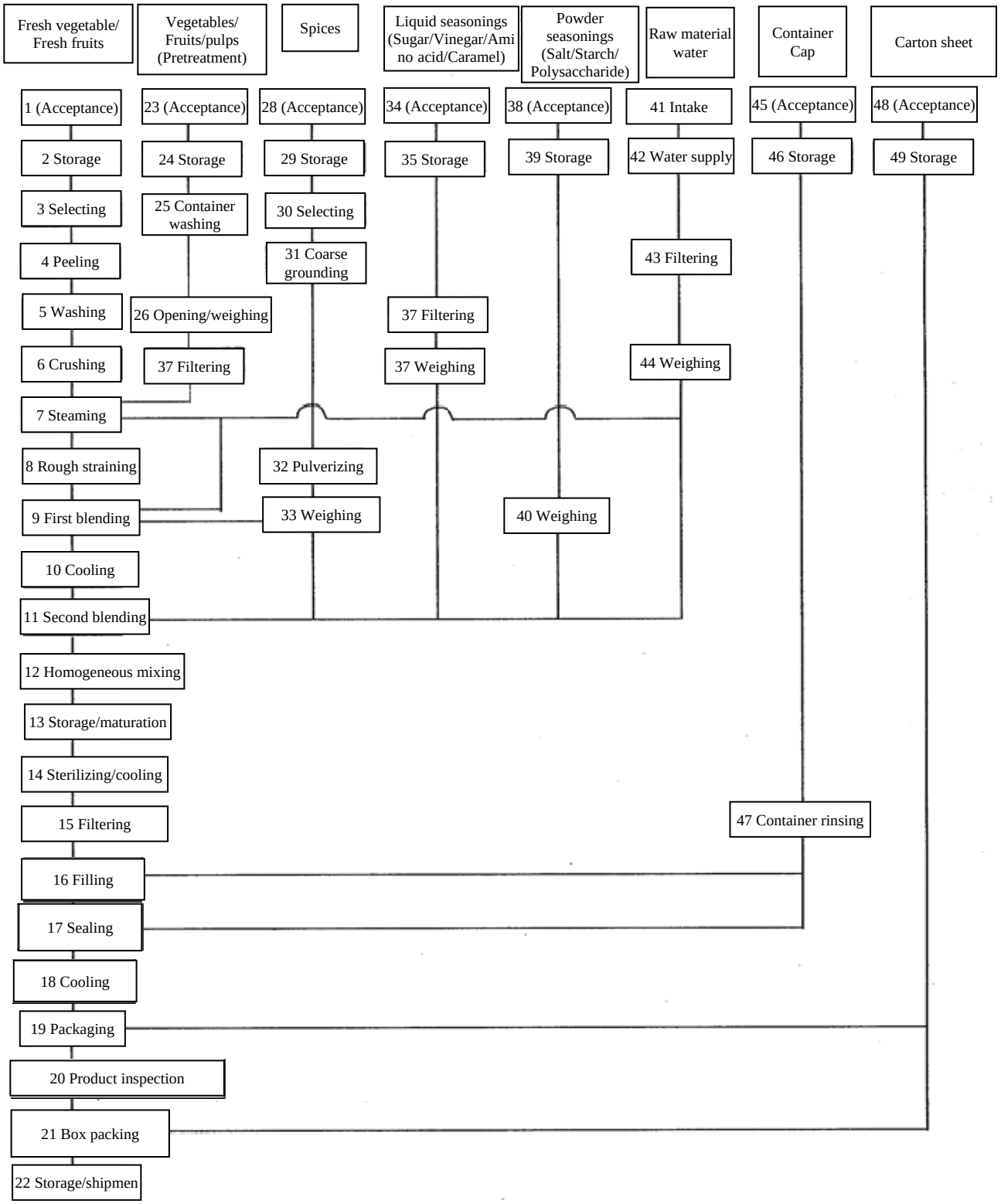

Fig. 6 Manufacturing process flow in the Worcester sauce plant

through flow planning. It is also inevitable to develop the manufacturing process flow by considering the movement of people and materials in accordance with the work time and the types of operations.

5.2 Risk Prevention by the HACCP System and Important Points of Flow Planning

5.2.1 Risk Prevention by the HACCP System

The 29 manufacturers investigated in this study are operated according to the production manuals on the basis of the HACCP system, which seems to play a crucial role for risk prevention. In this light, the procedure to apply the HACCP system and its risk prevention measures are illustrated as seven principles in Fig. 7.

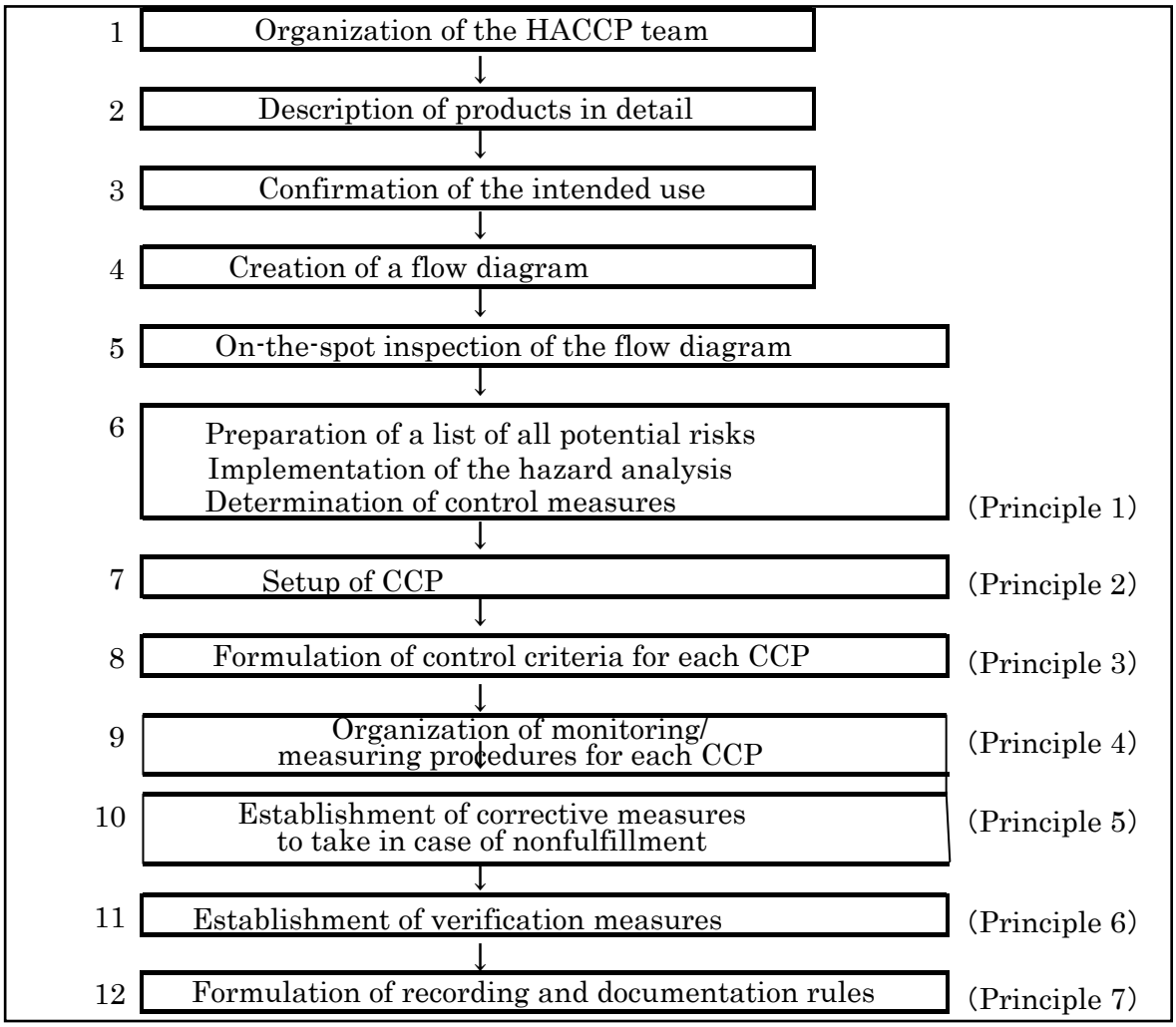

Fig. 7 Application of the HACCP system.

(1) Any latent hazards in all the manufacturing stages from the production of raw materials through the manufacturing and processing of foods to the final consumption are identified. The possible occurrence of hazards is analyzed and their prevention measures are clarified.

(2) Controlled places, procedures and operation phases to eliminate hazards or minimize the possibility of risk occurrence, namely Critical Control Point (CCP), are determined. In this case, CCP means check points necessary to prevent hazards detected through Hazard Analysis (HA). For example, where sterilization at high temperature is required in the

process, tasks such as temperature setting and monitoring need to be included in CCP.

(3) To verify that CCP is properly managed, control criteria to be met are set up.

(4) A systematic measurement or observation method to monitor the CCP management is established.

(5) Corrective measures to be taken when deviation of particular CCP from the control criteria is monitored are formulated.

(6) Verification measures (including test/inspection methods) to confirm the effective performance of the HACCP system are established.

(7) The above mentioned items, their relevant application measures, and the documentation management system are established.

5.2.2 Flow Planning in the Flow Diagram

All the stages in the manufacturing process from receipt of raw materials to shipment of final products are included in the flow diagram.

To create a flow diagram like those introduced in Section 3.1, some types of food plants need to use consecutive numbers for the operation process, and put B for biological hazards conceivable to occur in each stage, C for chemical hazards, and P for physical hazards.

It is also necessary to revise a flow diagram from the viewpoint of risk prevention as soon as the changes take place in the type of materials, manufacturing process, proportion and composition of ingredients, equipments, machines, tools and spatial layout.

5.3 Compound Flow Planning for Risk Preventative Buildings/Facilities

(1) Flow planning of raw materials and packaging materials

The flow lines of raw materials and packaging materials are just the same as the manufacturing process flow. They are moved in the following course: “dirty work zone” -> “semi-clean work zone” -> “clean work zone” -> “semi-clean work zone” -> “dirty work zone,” and finally shipped as products.

The following matters also need to be taken into consideration.

1) Two doors must be fixed between the “dirty work zone” and the outside to keep air shutoff.

2) Instruments and tools used outside should not be brought into the “dirty work zone”.

3) Carriages and carts used as a means of transport between work sections should not be moved from the “dirty work zone” to the “non-dirty work zone”. When goods need to be transported from the “dirty work zone” to the “non-dirty work zone” by any means, they should be cleansed of contaminants in advance. In this regard, the locations of washing rooms, their preparation rooms and storages of cleansed instruments are important in flow planning. Whether washing rooms are centralized or dispersed need to be examined in the stage of flow planning and layout planning.

4) What tend to be overlooked is a storage of goods-in-process. Careful consideration should be given to whether goods are temporarily placed or stored away before moving into the next stage as well as the size of the space to be saved.

(2) Flow planning of waste materials

From the viewpoint of risk prevention, when there is a possibility of contamination of products, one solution is the adoption of airtight storage, for which a carry-out route must be secured.

In compliance with the requirements of waste separation by type (e.g., industrial wastes, recyclable wastes and other specific wastes), appropriate containers should be prepared and distinguished by markings and colors.

The flow of waste treatment commonly observed in most food plants is: placement of containers in the production site, labeled airtight or not -> conveyance -> storage of industrial wastes -> conveyance of industrial wastes -> industrial waste disposal operators -> disposal.

The HACCP system stipulates that goods-in-process and wastes including defective pieces are separated strictly not to get unwanted articles into the

manufacturing line. It is also important to carry wastes out of the plant with great care and responsibility to prevent illegal dumping, by using the manifest system of industrial waste.

(3) Flow planning of wastewater

It is desirable to separate wastewater lines systematically by work zones, namely “dirty work zone,” “semi-clean work zone,” and “clean work zone.” It should be noted that drain pipes and drain ditches are always puddled with wastewater, causing a source of contamination.

The wastewater system in a food plant should be built up with the following lines except in special instances. But, some constructors may be ignorant of this matter. As a failure to keep requirements of sewage separation can be against the Sewerage Law, due attention must be paid.

(i) Wastewater from production process

Wastewater released from a production site (e.g., washing floor and machinery) -> grease-trap -> wastewater treatment -> discharged into a sewer or a river.

(ii) Cooling water

Unpolluted wastewater like cooling water for freezer -> recycling or wastewater treatment -> discharged into a sewer or a river.

(iii) Domestic wastewater

Wastewater from a dining room, offices and restrooms -> a septic tank (or discharged directly into a sewer) -> a river

(iv) Rainwater

Rainwater on the roof and roads -> discharged into a sewer or a river

Wastewater from production process or quality control will never be discharged into the line which flows into a river with no effluent treatment. Because drain pipes in a food plant tend to be clogged with food refuse and grease, and infested with insects, the facilities should be structured to facilitate regular cleaning.

(4) Flow planning of people

Food contamination most adversely affects “people.” Here, “people” can be classified into primary operators who are engaged directly in operation, secondary operators who are engaged indirectly in operation, external traders such as conveyancers and people in general.

(i) Primary operators

Contaminant attached to working clothes and finger tips in the dirty work zone is possibly brought into the non-dirty work zone. Its transfer from the “dirty work zone” to the “non-dirty work zone” should be prevented in the same way as the flow line of goods. Contaminated shoes also pollute the floor. As the operators in charge walk around, contamination spreads widely. As the operators in charge shun direct contacts with external traders, so direct contacts between the operators in the “dirty work zone” and those in the “non-dirty work zone” should be avoided.

Proper arrangements are required for risk prevention. For example, goods are sent from the “dirty work zone” and received in the “non-dirty work zone” by way of a delivery zone.

(ii) Secondary operators

Entry into the manufacturing work section should be limited to necessary operational requirements such as maintenance and inspection of machinery and equipment supervised by facility managers.

(iii) External traders (e.g., conveyancers)

External traders such as conveyancers should avoid entering the work section or directly contacting with the operators when they carry raw materials and ingredients in and products out.

(iv) People in general

To allow outsiders unconditional access to the work section is one of the prohibitions. If it is absolutely necessary for them to enter in, the same procedure must be followed as the operators take: wearing working clothes and shoes, washing the hands, etc.

(5) Flow planning of air

Like the flow line of people, air should not be flown from the “dirty work zone” to the “non-dirty work

zone," or from the "semi-clean work zone" to the "clean work zone". According to the airflow management, the basic line should be: "clean work zone" -> "semi-clean work zone" -> "dirty work zone" -> "general area." When zoning is implemented according to the cleanness, the following matters must be taken into consideration: (i) no outdoor air flowing directly into the work section; (ii) no air flowing from the dirty work zone to the non-dirty work zone: and (iii) ventilating not the entire room but only selected areas to minimize unnecessary discharge.

What should be noted in designing an air-conditioning and ventilation system for a food plant is that a large volume of hot water is used to get rid of grease when production machines and floors are cleansed. A highly humid environment is most favored by microorganisms. If steam is not aptly controlled, dew forms on the ceilings and walls, where mold and bacteria grow. Thus, there is danger of mixing those harmful substances with foods.

Not confined to food plants, "air" management tends to be made light of. There are dust, microorganisms, small insects and toxic substance in the air. Fortunately, people have resisting power and remain healthy by inhibiting the onset of a disease and discharging harmful substances from the body even if they are taken into the body. But a product accident is likely to occur when those substances cling to foods.

When zoning is implemented in response to the cleanness, it is important to control the both intake and exhaust air accordingly. Airflow control in itself is not so difficult. Like water, air flows from a high-pressure area to a low-pressure area. It is called airflow. The ordinary air management is to control this airflow.

In the airflow management, the following three matters are crucial.

(i) No outdoor air flowing directly into the work section.

(ii) No air flowing from the "dirty work zone" to the "non-dirty work zone."

(iii) Ventilating not the entire room but only selected areas to minimize unnecessary discharge.

Because hot water increases heat load greatly, it is inefficient to cool and dehumidify the air by the air-conditioning equipment. The production lines need to be suspended while cleaning works are under way. So, it is necessary to install a ventilator which is powerful enough to swiftly eliminate heat and vapor generated during cleaning.

In the culinary section where ingredients are cooked to make food products like fried rice, heat increases the calorific value within the room. In designing a new work section, the installation of ventilatory devices such as a fume hood and a local exhaust ventilation system near a cooking stove must be taken into consideration. In addition, the placement of air outlets and spot air conditioners needs to be planned.

Airflow is a crucial factor in planning an HACCP plant. Air conditioning zoning and ventilated airflow should be examined together on the flowchart of the entire building. Then, airflow and floor planning are checked. Concerning properties of interior furnishings and fittings (e.g., heat insulation, air tightness and louvers), consultations with an air conditioning engineer should be sought. It is also important to determine the places to remove dust, to separate lines and to fix filters in the course of airflow. If a filter is in the clean work zone, dirty substances may be scattered about when an old filter is replaced. The details on the clean work zone will be discussed in the second report as a follow-up.

6. Summary

In this paper, the HACCP system practiced in food plants is reviewed and the investigation carried out for this study was outlined, where three food plants including a soy sauce manufacturer are picked up to examine their flow planning of such elements as raw materials/packaging materials, waste materials, wastewater, people and air. As pointed out in this paper, the examination of compound flow planning is

inevitable from the viewpoint of risk preventive buildings and facilities. That is to say, it is essential to analyze where risks lurk around by examining the flow planning of (1) raw materials and packaging materials, (2) waste materials, (3) wastewater, (4) people, and (5) air.

Acknowledgment

This research was completed with the assistance of the staff in the relevant engineering societies and industries, and the federation of industrial cooperative associations, who provided precious opinions and reference materials. Also, deep gratitude is owed to Aya Hoshuyama, Tatsuhito Matsushima, and Sho Ishizuka, as students at Toyo University then, for their help in sorting out voluminous data.

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