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Technical guide to fish canning

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Technical guide to fish canning

by

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Canning is a long established form of food preservation. It provides nutritious safe food in a convenient form for the ultimate consumer and without the need for refrigeration during storage and transportation. Processing may take place in areas where the raw material food is available providing the possibility of employment for large numbers of people and the opportunity for trade with the major retail organizations across the world. In theory the canning process is simple. Food is prepared, placed inside a can, the can is sealed and heat sterilized and cooled before labelling storage and despatch. Technically however the principal objectives are the destruction by heat of microorganisms that could cause poisoning or spoilage and the prevention of post process infection during cooling. In addition the heat treatment provided also cooks the food making it convenient for subsequent use. Fish canning on rare occasions has been associated with fatal incidents of food poisoning and it is imperative that all processes are carried out in accordance with recognized good manufacturing practices if the health of the consumer is to be protected.

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LIST OF ACRONYMS

AOAC	Association of Official Analytical Chemists
AOL	Actual overlap
BHB	Body hook butting
CCP	Critical Control Point
CFIA	Canadian Food Inspection Agency
CFR	Code of Federal Regulations
CMI	Can Manufacturers Institute
CN	Combined nomenclature
DPD reagent	Analytical method for determining chlorine residual utilizing the reagent DPD
DWI	Drawn and wall ironing
EU	European Union
FDA	Food and Drug Administration
GFSI	Global Food Safety Initiative
GMO	Genetically modified organism
HACCP	Hazard Analysis Critical Control Point
HPLC	High pressure liquid chromatography
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LACF	Low acid canned foods
MSC	Marine Stewardship Council
ORA	Office of Regulatory Affairs
QUID	Quantitative Ingredient Declaration
SHP	Slowest heating point
SWP	Steam Working Pressure
USA	United States of America

1. CANNING PRINCIPLES

1.1. INTRODUCTION TO CANNING

Canning is a long established form of food preservation. It provides nutritious safe food in a convenient form for the ultimate consumer and without the need for refrigeration during storage and transportation. Processing may take place in areas where the raw material food is available providing the possibility of employment for large numbers of people and the opportunity for trade with the major retail organizations across the world. In theory the canning process is simple. Food is prepared, placed inside a can, the can is sealed and heat sterilized and cooled before labelling storage and despatch. Technically however, the principal objectives are the destruction by heat of microorganisms that could cause poisoning or spoilage and the prevention of post process infection during cooling. In addition, the heat treatment provided also cooks the food making it convenient for subsequent use.

Fish canning has on rare occasions been associated with fatal incidents of food poisoning. It is imperative that all processes are carried out in accordance with recognized good manufacturing practices if the health of the consumer is to be protected.

Since the initial publication of the Fisheries Circular No. 784 by the Food and Agriculture Organization in 1985 (FAO, 1985), there has been even greater emphasis on Food Safety. HACCP (Hazard Analysis Critical Control Point) has become established as the management tool for the identification and control of hazards to food safety, and the establishment of the Global Food Safety Initiative (GFSI) by the major retail organizations has meant the practical requirement for food manufacturers to comply with one or more of the food standards accredited against the requirements of the GFSI.

1.2. COMMERCIAL STERILITY

In the canning of fish products it is necessary to obtain a condition during heat processing known as Commercial Sterility. This implies the total destruction of all pathogenic (food poisoning) microorganisms and the destruction of those more heat resistant microorganisms that could cause spoilage under those ambient conditions likely to be encountered during the intended storage and distribution of the product.

Fish products have a pH value in excess of 4.5 and as such will support the growth of pathogenic microorganisms. The most heat resistant pathogen is considered to be the spore forming microorganism *Clostridium botulinum*. Consequently thermal processes are established to ensure the destruction of this organism.

Mathematically the chances of survival of a single spore are calculated to be less than one in 10^{12} containers. In addition to the pathogens however, there are also spore forming spoilage organisms known as thermophiles. These are considerably more heat resistant in which case the thermal process necessary to ensure complete destruction might greatly reduce the quality of the food. These organisms will only metabolize at an optimum temperature of 55 °C however, and if canned products are intended for more temperate climates, may be disregarded.

1.3. MATHEMATICS OF HEAT STERILIZATION OF CANNED FOODS

It is necessary to be able to calculate the amount of heat to be applied during the sterilization process to provide the required condition of commercial sterility. It has been established experimentally that when subjected to lethal degrees of heat, microorganisms die in a logarithmic manner. That is to say that at a constant temperature, a given percentage of organisms will die in the same time. The **D** value is a constant for a given organism and a given temperature and is the time required for the death of 90 percent of organisms at that temperature (For example the time necessary to reduce the spore population from 1000 to 100 or from 100 to 10).

Canning is typically conducted at a sterilization temperature of 121.1 °C (250 °F) and at this temperature the $D_{121.1}$ values of typical microorganisms of relevance to the canning of fish are:

B. coagulans	0.01–0.07 minutes
C. sporogenes (P.A 3679)	0.1–1.5 minutes
C. botulinum A & B	0.1–0.23 minutes
D. nigrficans	2.0–3.0 minutes
C. thermosaccharlyticum	3.0–4.0 minutes
B. steareothermophilus	4.0–5.0 minutes

For example if 10^4 spores of *C. botulinum* were subjected to 121.1 °C for 0.23 minutes the population would be reduced to 10^3 and so on.

It is essential that all of the contents of a can are fully sterilized. Canned fish products generally heat by conduction rather than convection. During sterilization, the actual temperature experienced at the SHP (slowest heating point) within a can, will be changing continuously. The retort, in which sterilization takes place, will rapidly reach its operating temperature and then stabilize at a constant temperature, until the onset of cooling. The temperature of the SHP (normally the geometric centre) will rise more slowly, only approaching the retort temperature towards the end of the process. Indeed, the temperature of the SHP may even continue to rise for a short time after the commencement of cooling.

In order to calculate the total effect of heating on microbial destruction, it is essential to know how the **D** value changes with change in temperature. The **z** value is defined as the number of degrees necessary to effect a tenfold change in the D value. The z value for *C. botulinum* is considered to be 10 °C. Therefore, if the D value is 0.23 minutes at 121.1 °C, it will be 2.3 minutes at 111.1 °C or 0.023 minutes at 131.1 °C.

The overall sterilizing effect of a heat process is provided numerically by a parameter known as the **Fo** number. By convention, exposure to a temperature of 121.1 °C for one minute equates to an **Fo** value equal to one. It is possible to calculate the equivalent lethal effect of all temperatures experienced at the SHP using a further parameter known as the Lethal Rate, **L**. In effect, the lethal rate is proportional to the inverse of the D value. As the temperature rises the lethal rate also rises in an exponential manner. The Lethal Rate provides the relative killing effect to that of L = 1 at 121.1 °C.

Lethal rates may be calculated for any temperature using the formula:

$L=10^{((T-Tref)/z)}$ where T_{REF} = 121.1 and z = 10

Tabulated figures for Lethal Rates based on 121.1 °C and z = 10 °C, for temperatures between 90 °C and 130 °C in 0.1 °C are listed in Table 1 below.

Table 1. Tabulated figures for Lethal Rates

	0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
90	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
91	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
92	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
93	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
94	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
95	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
96	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
97	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
98	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
99	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008
100	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.010
101	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.012	0.012
102	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.015	0.015
103	0.015	0.016	0.016	0.017	0.017	0.017	0.018	0.018	0.019	0.019
104	0.019	0.020	0.020	0.021	0.021	0.022	0.022	0.023	0.023	0.024
105	0.025	0.025	0.026	0.026	0.027	0.028	0.028	0.029	0.030	0.030
106	0.031	0.032	0.032	0.033	0.034	0.035	0.035	0.036	0.037	0.038
107	0.039	0.040	0.041	0.042	0.043	0.044	0.045	0.046	0.047	0.048
108	0.049	0.050	0.051	0.052	0.054	0.055	0.056	0.058	0.059	0.060
109	0.062	0.063	0.065	0.066	0.068	0.069	0.071	0.072	0.074	0.076
110	0.078	0.079	0.081	0.083	0.085	0.087	0.089	0.091	0.093	0.095
111	0.098	0.100	0.102	0.105	0.107	0.110	0.112	0.115	0.117	0.120
112	0.123	0.126	0.129	0.132	0.135	0.138	0.141	0.145	0.148	0.151
113	0.155	0.158	0.162	0.166	0.170	0.174	0.178	0.182	0.186	0.191
114	0.195	0.200	0.204	0.209	0.214	0.219	0.224	0.229	0.234	0.240
115	0.245	0.251	0.257	0.263	0.269	0.275	0.282	0.288	0.295	0.302
116	0.309	0.316	0.324	0.331	0.339	0.347	0.355	0.363	0.372	0.380

Table 1 (continued)

	0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
117	0.389	0.398	0.407	0.417	0.427	0.437	0.447	0.457	0.468	0.479
118	0.490	0.501	0.513	0.525	0.537	0.550	0.562	0.575	0.589	0.603
119	0.617	0.631	0.646	0.661	0.676	0.692	0.708	0.724	0.741	0.759
120	0.776	0.794	0.813	0.832	0.851	0.871	0.891	0.912	0.933	0.955
121	0.977	1.000	1.023	1.047	1.072	1.096	1.122	1.148	1.175	1.202
122	1.230	1.259	1.288	1.318	1.349	1.380	1.413	1.445	1.479	1.514
123	1.549	1.585	1.622	1.660	1.698	1.738	1.778	1.820	1.862	1.905
124	1.950	1.995	2.042	2.089	2.138	2.188	2.239	2.291	2.344	2.399
125	2.455	2.512	2.570	2.630	2.692	2.754	2.818	2.884	2.951	3.020
126	3.090	3.162	3.236	3.311	3.388	3.467	3.548	3.631	3.715	3.802
127	3.890	3.981	4.074	4.169	4.266	4.365	4.467	4.571	4.677	4.786
128	4.898	5.012	5.129	5.248	5.370	5.495	5.623	5.754	5.888	6.026
129	6.166	6.310	6.457	6.607	6.761	6.918	7.079	7.244	7.413	7.586
130	7.762	7.943	8.128	8.318	8.511	8.710	8.913	9.120	9.333	9.550

1.4. THERMAL PROCESS EVALUATION

For low acid foods, where the pH is > 4.5, as is the case with canned fish, it is convention that the minimum **Fo** value should be 3. This figure of 3 equates to the twelve decimal reductions for the spores of *C. botulinum*. In practice, the target **Fo** values are higher in order to provide extra levels of food safety and in some cases may be specified by the customer retail organization. Typically, **Fo** values in the region of 6–8 are used.

As stated above it is probable that temperature will continue to rise at the SHP during the initial stages of cooling adding to the overall **Fo** attained. Certain retail organizations however, stipulate a minimum **Fo** value during the sterilizing phase of the thermal process.

Factors affecting the **Fo** value achieved during processing include the can size and shape, the initial temperature of the food, the manner of packing of the food within the can, the packing of cans within the retort crate and the retort temperature. In evaluating the thermal process it is essential that all relevant factors are fully specified.

In the practical evaluation of thermal process, a temperature probe is positioned within the can at the SHP, and temperatures recorded at specified time intervals (conveniently at minute intervals). From tables, the lethal rates corresponding to each individual temperature may be obtained. These may be added together to obtain the resultant **Fo** value. Commercial equipment, of varying degrees of cost and sophistication is readily available for the experimental determination of **Fo** values.

Temperature measuring devices used are normally Type T Copper Constantan thermocouples or more sophisticated data loggers. Such equipment automatically calculates the **Fo** value and provides permanent records (hard copy and/or computer based) of the experiment. It is also important that such experimental work is undertaken by somebody competent, who fully understands the implications of such work. It would be normal for a canning company to appoint a Thermal Process Manager having the ultimate responsibility for matters relating to the definition of and application of the thermal processes used within the company.

There are also consultant organizations able to provide on-site help to companies in the definition of their thermal processes. Such help may initially be expensive, but as it is required relatively infrequently, it may be cheaper than investing in equipment.

Picture 1. ELLAB dataloggers used for thermal process evaluation

1.5. THE TRAPEZOIDAL INTEGRATION METHOD

The trapezoidal integration method provides a relatively inexpensive practical possibility for the determination of the lethal effect of a thermal process. A thermocouple is situated at the SHP within a can and temperatures recorded at standard time intervals.

The Fo value is calculated by summing all of the L values corresponding to each of the recorded temperatures and multiplying by the standard time interval between readings. It is necessary that when adding the lethal rates the first and final values are halved. This is because these two values are averaged from readings taken at time zero and the end of the heat process cycle.The trapezoidal method also allows simple calculation of the contribution to the total process lethality of both heating and cooling stages, of the overall retort cycle.

Table 2 below provides a worked example in which the temperature at the SHP within a can was recorded at five minute intervals during a process for 60 minutes at 121.1 °C. The total Fo of the process is found by multiplying the summed L values of 2.925 by the time interval of five minutes to give the final Fo value of 14.6 minutes.

To calculate the Fo for the heating phase alone, the sum of the L values at time 25 and 60 minutes (0 and 0.776) is halved and this value (0.388), is added to the sum of L values from time 30 to 55 minutes. This gives 1.730, which when multiplied by 5, yields a Fo of 8.6 for the lethality attained prior to the commencement of cooling.

Table 2. SHP in a can recorded at 5-minute intervals

Time from retort reaching sterilization temp.	Temperature at SHP of can °C	Lethal rate	Cumulative lethal effect	Lethal rate x time interval of 5 min. Fo
0	24	0		
5	24.5	0		
10	34	0		
15	54	0		
20	72.5	0		
25	87	0 x 0.5		
30	98	0.005		
35	105	0.025		
40	110.5	0.087		
45	114.5	0.219		
50	117	0.389		
55	119	0.617		
60	120	0.776 x 0.5	1.730	8.6
Steam off				
65	120	0.776		
70	106	0.031		
75	88	0	2.925	14.6

Further details on thermal process evaluation may be found in the Campden BRI publication Heat processing of packaged foods – G56 Guidelines for establishing the thermal process 2008.

2. PRINCIPAL ELEMENTS OF LEGISLATION COVERING THE MANUFACTURE OF CANNED FISH PRODUCTS

2.1. INTRODUCTION

Canned fish is generally exported from the country of manufacture to distant markets, where legislation is in force in order to protect the health of the consumer, to regulate and control the process of importation, and to define those parameters relating to the trading standards that provide for consumer understanding and satisfaction. It is vital therefore, that the manufacturer is fully aware of such legislation and has necessary mechanisms in place to monitor any changes in legislation as they occur. European and North American regulations are readily available from the internet.

In addition to legislation, there are voluntary codes of practice such as the MSC (Marine Stewardship Council) scheme that is concerned with the sustainability of fisheries and compliance with which, is increasingly required by a number of the major international retail organizations.

Principle markets for canned fish products include Europe and North America where legislation is enacted respectively by the European Union (EU), the FDA (Food and Drug Administration) of the United States and the CFIA (Canadian Food Inspection Agency) of Canada.

2.2. LEGISLATION OF THE EUROPEAN UNION

In 2004 the EU consolidated food hygiene and inspection legislation in a series of regulations. Such regulations must be adopted, without local modification, by all member countries of the EU. The most important of these are:

- Regulation No. 852/2004 (EC, 2004a) on the hygiene of foodstuffs;
- Regulation No. 853/2004 (EC, 2004b) laying down specific hygiene rules for foods of animal origin;
- Regulation No. 854/2004 (EC, 2004c) laying down specific rules for the organization of official controls of products of animal origin intended for human consumption.

Importantly, Regulation 852/2004 requires that food manufacturers employ a HACCP system based on the recommendations contained in Codex Alimentarius for the management of food safety and there are specific requirements relative to the manufacture of heat processed products:

- Any heat treatment is to raise every part of the product to a given temperature for a given period of time and to prevent the product from becoming contaminated during the process;
- Food business operators must check regularly the main relevant parameters (particularly temperature, pressure, sealing and microbiology), including the use of automatic devices; and

- The process should conform to an internationally recognized standard (e.g. for pasteurization or sterilization).

There is also reference to Regulation 178/2002 (EC, 2002a) that defines the need for traceability of foods as an essential element in the assurance of food safety.

The EU also publishes a list in accordance with Regulation 854/2004 of third countries (i.e. those countries outside the EU), from which imports of fish products are permitted. Amongst the specific requirements are the need for compliance with identification marking, standards for processing establishments and operational processes described in 853/2004.

Commission Decision 2007/275/EC (EC, 2007a) provides a list of animals and animal products, including fish, that are subject to controls at border inspection posts, both in relation to product health and also import tariffs whenever applicable. Border inspections post checks are carried out in conjunction with customs officials.

The EU also monitors and approves the Competent Authorities, who in turn are responsible in third countries for the inspection and approval of fish processing plants.

The list of products subject to inspection is defined by reference to the CN (combined nomenclature) established by Council Regulation (EEC) No. 2658/87 (EC, 1987) on the tariff and statistical nomenclature. There are CN codes defining the species of fish that comply with trade descriptions for marketing of sardines, tuna, and bonito products within the EU.

Commission Regulation No. 2073/2005 (EC, 2005a) on the microbiological criteria for foodstuffs contains a table of maximum values for histamine in fish products. For fish species associated with a high amount of histidine, typically tuna, mackerel and sardines, the mean value should be ≤ 100 mg/kg of histamine and the maximum value is 200 mg/kg. In commercial practice however, it is likely that the major retail or trading organizations would impose the significantly lower maximum figure of 50 mg/kg.

Further regulations with specific relevance to canned fish products include; Council Directive 2003/89/EC (EC, 2003a) sets out the requirements for the labelling of allergens. In practice, it is recognized that the common names of the fish themselves, tuna, sardines and so on, provide clear indication for consumers and it is unnecessary to further state fish as an allergen on labelling material. Further allergen materials as listed in the directive that are included in recipe packs, must be individually declared as allergens.

2.2.1. Food labelling in the EU

Food labelling requirements in the EU are defined within Council Directive 2000/13/EC (EC, 2000) and updated by Directive 2009/83/EC (EC, 2009). There are specific paragraphs relating to the:

- Name of food;
- Ingredient listing;
- Quantitative ingredient declaration;
- Date marking;
- Name and address;
- Origin marking;
- Instructions for use;
- Nutrition labeling;
- Health and nutrition claims; and
- Food assurance schemes.

Traceability has assumed great importance as an integral part of quality assurance management. EC Directive 89/396 (EC, 1989) describes the lot marking requirements for products such as canned fish. In practice, ink jet coding machinery has provided the possibility to record details of the individual double seaming and retorting machines used as well as the time and date of manufacture. Empty cans are even available from the can makers with individual identification codes.

There are a number of regulations concerned with contaminants in food. Two of specific importance to canned fish are Regulation No. 221/2002 (EC, 2002b), which defines the limits for heavy metals, lead, cadmium and mercury, and Regulation No. 1895/2005 (EC, 2005b) that relates to the use of epoxy derivatives BADGE, BFDGE, and NOGE that may be used in the preparation of lacquers, used to line the inside of cans and which are in direct contact with food. It is important that the canner receives specific confirmation from the can supplier that all cans supplied, comply with materials in contact with food legislation.

2.3. LEGISLATION OF THE UNITED SATES OF AMERICA (USA)

The FDA (Food and Drug Administration) is the regulatory body in the USA with responsibility for the safety of canned foods, which are produced internally, or which are imported into the country. Within the FDA, the Office of Regulatory Affairs (ORA) is the field agency with the practical task of providing inspection for the enforcement of regulatory requirements for both domestic and imported food products. Primary legislation is described within the nine chapters of the Food, Drug and Cosmetic Act originally passed by Congress in 1938 and subsequent rules are published in the Code of Federal Regulations (CFR).

Chapter VIII of the FDC Act is specifically dealing with imports and exports and is concerned that imported food is not unsanitary, adulterated or misbranded in any way, or permission for entry to the USA will be not granted.

More recently, the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 was published in the aftermath of the terrorist attack on the USA of September 2001. This has a number of requirements for companies wishing to export canned foods to the USA.

Section 305 requires that all foreign facilities that manufacture food for human or animal consumption in the USA, to register with the FDA. (This is in addition to registration as a producer of low acid canned foods under 21 CFR 108).

Section 306 requires the establishment and maintenance of records by persons who manufacture, process, pack, transport, distribute, receive, hold or import foods. The traceability provided by such records may be used to assess whether there is credible threat of serious adverse consequences of death to humans or animals.

Section 307 requires that importers or brokers of canned foods provide information to both the FDA and the Bureau of Customs and Border Protection when foods are due to arrive in the USA. Such information is required by the FDA not less than five days prior to arrival in the USA.

2.3.1. Low acid canned foods (LACF)

The FDA recognizes the LACF (canned products with pH $\geq$ 4.6) category of food products in the form of specific legislation.

21 CFR 108 requires the registration of each processing facility and the filing of the thermal process used in the manufacture of each product with the FDA. Such process details should include, but are not limited to, the processing method, type of retort or other thermal processing equipment employed, minimum initial temperatures, times and temperatures of processing, sterilizing value (Fo), or other equivalent scientific evidence of process adequacy, critical control factors affecting heat penetration, and source and date of the establishment of the process, for each such low-acid food in each container size.

21 CFR 113 defines the requirements for thermally processed low-acid foods packaged in hermetically sealed containers. The regulation is based on HACCP and defines in detail the specifications for, and manner, of good manufacturing practice for the operation of saturated steam retorts.

21 CFR 123 is commonly known as the Seafood HACCP regulation. Hazard analysis must be performed on each individual product manufactured and requires an HACCP plan when the hazard analysis reveals one or more safety hazards that are reasonably likely to occur.

Importers of canned seafood products must also take affirmative steps to verify compliance with the regulation that may include:

- Obtaining from the foreign processor the HACCP and sanitation monitoring records required by this part that relate to the specific lot of fish or fishery products being offered for import;

- Obtaining either a continuing or lot-by-lot certificate from an appropriate foreign government inspection authority, or competent third party, certifying that the imported fish or fishery product is, or was, processed in accordance with the requirements of this part;
- Regularly inspecting the foreign processor's facilities to ensure that the imported fish or fishery product is being processed in accordance with the requirements of this part;
- Maintaining on file a copy, in English, of the foreign processor's HACCP plan, and a written guarantee from the foreign processor that the imported fish or fishery product is processed in accordance with the requirements of the part;
- Periodically testing the imported fish or fishery product, and maintaining on file a copy, in English, of a written guarantee from the foreign processor that the imported fish or fishery product is processed in accordance with the requirements of this part; or
- Other such verification measures as appropriate that provide an equivalent level of assurance of compliance with the requirements of this part.

It should be noted that the hazard of *C. botulinum* toxin is covered within the established canning regulations and need not be included within the HACCP plan. All other hazards that might be expected to occur should be included.

2.3.2. FDA guides

The FDA publishes a number of guides that provide useful information for the processor of canned fish products. These include:

- The FDA's Acidified and LACF web page[1] contains amongst other information instructions for establishment registration and processing filing.
- The Fish and Fishery Products Hazards and Controls Guidance[2] contains 21 chapters on the types of physical, microbiological and chemical hazards that might be associated with fish products.
- The Salmon Control Plan[3], providing advice in good manufacturing practices for all processors of canned salmon products, is produced annually by the Seafood Products Association based in Seattle, Washington State, USA.

[1] http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/AcidifiedLACF/default.htm
[2] http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm2018426.html
[3] http://www.spa-food.org/Downloads/events/2011%20Salmon%20Control%20Plan-Final.pdf

2.4. CANADIAN LEGISLATION

Food legislation in Canada is controlled by the Canadian Food Inspection Agency (CFIA). There are specific requirements relating to the operation of fish canneries that are described in the Fish and Seafood Facilities Inspection Manual, Chapter 6, Subject 2 Operations Canneries[4]. Headings include:

- Cannery operations;
- Empty container handling;
- Retort operations;
- Seam inspection procedures;
- Sterilization processes and procedures; and
- Warehousing/Post-process handling.

[4] www.inspection.gc.ca

3. RAW MATERIALS

The principle raw materials used in the canning of fish are clearly the fish itself and the can in which it is packaged, sterilized and sold to the consumer. Additional materials may also be used however, and include salt, vegetable oil, tomato paste, sugar and spices. The types of fish used in canning include importantly tuna, salmon, sardines and mackerel, but other suitable species include herring, clams, mussels, oysters, shrimps and octopus.

Picture 2. Sardine fishing boats in the Moroccan port of Safi

Codex standards 70–1981, 94–1981 and 3–1981 include definitions of the species of tuna and bonito, sardines, and salmon respectively that may be used for canning, and the further standard 119–1981 for finfish, provides general guidance for all other species. There is also extensive listing, within the standards for tuna and finfish, of all the minor ingredients including thickening or gelling agents, starches, acidity regulators and natural flavours that may be used. Such additives are not permitted, however, in the manufacture of canned salmon.

3.1. PRINCIPAL SPECIES OF FISH USED COMMERCIALLY IN CANNING

Tuna	
Albacore	*Thunnus alalunga*
Yellowfin	*Neothunnus albacores*
Bluefin	*Thunnus thynnus*
Skipjack	*Katsuwonus pelamis* (syn. *Euthynnus pelamis*)
Bigeye	*Thunnus obesus*
Blackfin	*Thunnus atlanticus*
Black Skipjack	*Euthynnus lineatus*
Longtailed	*Thunnus tongoll*
Little tunny	*Euthynnus alleteratus*
Little tuna	*Euthynnus affinis* or *E.yaito*
Atlantic bonito	*Sarda sarda*
Pacific bonito	*Sarda chilensis* or *S.lineolata*
Tropical bonito	*Sarda orientalis* (Atlantic, Pacific and Indian oceans)
Sardines/Pilchards	
Mediterranean Atlantic	*Sardina pilchardus (Walbaum)*
Pacific	*Sardinops caeruleus*
Goldstripe sardinelle	*Sardinella gibbosa*
Japanese Pilchard	*Sardinops melanostictus*
Picton herring/Australia	*Sardinops neopilchardus*
Pilchards Europe/Atlantic	*Sardina pilchardus*
Californian pilchard	*Sardinops caerulea*
Chilean pilchard	*Sardinops sagax*
Japanese pilchard	*Sardinops melanostica*
South African pilchard	*Sardinops ocellata*
Herring / Mackerel/Anchovies	
Atlantic herring	*Clupea harengus*
Pacific herring	*Clupea pallasii*
Round herring	*Etrumeus teres*
Sprats	*Sprattus sprattus*
Argentinean anchovy	*Engraulis anchoita*
Californian anchovy	*Engraulis mordax*
Peruvian anchovy	*Engraulis ringens*
Japanese anchovy	*Engraulis japonica*
Salmon	
Chinook/King	*Oncorhynchus tschawytscha*
Red/Sockeye	*Oncorhynchus nerka*
Chum	*Oncorhynchus keta*
Coho	*Oncorhynchus kisutch*
Pink/Humpback	*Oncorhynchus gorbuscha*
Cherry salmon	*Oncorhynchus masou*
Atlantic salmon	*Salmo salmar*

3.2. DEFINITION OF SARDINES

It should be noted that within the EU, there is specific legislation that defines the species which may be used in the marketing of canned fish products. In particular, there are specific requirements defining the species of fish that may be marketed as sardines or tuna and bonito products. European Regulation No. 1181/2003 (EC, 2003b) specifies that only products made from *Sardina pilchardus* Walbaum may be marketed simply as sardines. Sardine-type products made from other sardine species must in addition carry the Latin name for the species used. Similarly, Regulation No. 1536/92 defines the species that may be used in the marketing of canned tuna and bonito. In the case of tuna products the species used must be from one of the following: Albacore, Yellowfin tuna, Bluefin tuna, Bigeye tuna, other species of the genus Thunnus, or Skipjack tuna. Suitable species of bonito are similarly listed.

3.3. APPROXIMATE YIELDS FROM FISH

Table 3 provides information on the possible yields that may be obtained during the processing of specific species of fish. Items are quoted as a percentage of the total weight of fish.

Table 3. Yields obtained during the processing

Species	Head	Skin & Flesh	Bones	Fins	Viscera	Tonne/m^2
Atlantic herring	12.5	62.2	6.5	1.5	15.0	0.91
Sardines	21.0	58.0	6.5	2.5	9.5	0.85
Atlantic mackerel	22.5	52.0	8.0	1.0	19.5	0.96
Tuna	18.0	64.0	8.0	2.0	8.0	
Pink Salmon	16.0	71.0		5.0	8.0	0.95

3.4. SUSTAINABILITY OF FISHERIES

The major global supermarkets, which are the main purchasers of canned fish products, are becoming increasingly concerned with the economic and social problems associated with the depletion of fisheries and the consequent need for the promotion of sustainability. Many are now committed to the sourcing of products made from wild fish caught in accordance with the standards of ecological organizations, such as the Marine Stewardship Council. There are two standards; one for sustainable fishing and one for traceability. Fisheries are certified following annual audit against the MSC standard and subsequent MSC labeled canned fish products come from, and may be traced back, to a sustainable fishery.

3.5. PURCHASING OF FISH

The quality of raw material is the key factor in determining the quality of the finished product. The contract between the cannery and the supplier of fish should specify, as far as possible, those factors that are measurable and which have a direct influence on quality and also yield during processing. Such factors may include: traceability information, fish species, size grading, delivery temperature, freedom from damage or

physical defects, and compliance with legislation, such as those regarding heavy metals or histamine content.

The sourcing of fish in relation to production demand is a critical issue with respect to the commercial success of the cannery. In the case of small canneries, contracts may be made with local fishermen and there may be obligation to take all of the catch. If this exceeds the daily requirement of the factory, then it will be necessary to provide refrigerated storage until processing is possible, alternatively to allow the sale of the fish to another company.

Small local boats that are at sea for a few days at most, will be required to pack the catch in relatively small boxes together with ice. In order to minimize enzymic, or microbiological deterioration of the fish, it is necessary that the temperature is reduced as quickly as possible after catching, to 0 °C.

The local veterinary authority may specify the amount of ice to be packed with a certain weight of fish. In addition, it may be part of the contractual arrangement between the cannery and the fishing boat that the cannery provides the ice for the purpose. In this case, ice making plant is required and the water used to make ice should be of potable quality. The standard for drinking water is defined in the European Directive 98/83/EC (EC, 1998). The Recommended International Code of Practice for Fresh Fish (CAC, 1976), provides guidance for good manufacturing practice in the handling and preparation of fresh fish for canning.

Fresh tuna is used for canning by certain small canneries, but the great majority of tuna is purchased as a frozen commodity from international trading organizations. Large fish, such as tuna, are most often frozen on board during extended fishing trips to a temperature of about -14 °C using refrigerated sea water. Such fish may be further transferred to a reefer vessel having a refrigerated hold at -20 °C for storage, before delivery to the cannery. The delivery temperature will be ultimately dependent on the manner and time of transfer to the cannery, but should not be greater than -12 °C.

The cold store at the cannery should ideally be set to operate at a temperature of -20 °C. In the case of a fatty fish, such as mackerel, intended to be held in cold store during an extended season, a lower temperature of -30 °C should be used. The use of frozen fish necessitates a subsequent process of defrosting as part of the initial cannery operations.

3.6. EXAMINATIONS OF FISH ON RECEIPT

Fish should be examined on receipt at the cannery for compliance with specification by suitably trained quality personnel. Such testing might include:

- Check on documentation accompanying the delivery;
- Temperature;
- Size grading;
- Sensory evaluation for appearance, smell, texture, and freedom from damage;
- Determination of total amines as a measure of freshness, (TVBN or ABVT);
- Determination of histamine in appropriate species.

3.7. HISTAMINE

Certain scombroid species of fish including tuna, sardines and mackerels include a chemical substance called L-histidine. Post mortem, microbial activity can cause enzymic transformation of L-histidine to histamine. This latter substance is not destroyed during the canning process and if present in the finished product, may cause unpleasant reaction in consumers including nausea, vomiting, facial swelling and headaches. Regardless of the legal limits which are somewhat higher, for practical purposes the major retail organizations are unlikely to accept canned fish with a histamine content in excess of 50 mg/kg.

There are three methods of measuring the histamine content; spectrofluorimetry, HPLC (high pressure liquid chromatography) which is probably the most accurate method, and the more recently introduced and most rapid method, using ELISA test kits. In certain countries the competent authority may specify the method to be used for the determination of histamine in cannery laboratories. The competent authority may also conduct duplicate analysis of the company's products.

3.8. HEAVY METALS

Industrial processes, such as coal burning power plants, release pollutants such as mercury into the atmosphere and hence into rivers and finally to the sea. Mercury and other heavy metals may accumulate over lengthy periods in certain species of fish, including tuna and mackerel. Such contamination may also accumulate in the human body after consumption of contaminated products. Legal limits are specified for the heavy metals, lead, cadmium and mercury in fish products in the European Union (EC, 2002b). Typically the maximum level for mercury in tuna meat is 0.1 mg/kg.

3.9. CONTAINERS FOR HEAT STERILIZED FISH PRODUCTS

Heat sterilized fish products are predominantly packaged in metal packaging, or glass containers, used where there is advantage in visual appreciation of the product or retort pouches. The container is the most critical physical component in ensuring product safety. It is the container which provides integrity against the ingress of microorganisms, which could cause spoilage or food poisoning.

Cans are made from either steel in the form of tin plate, tin free steel, i.e. steel with a coating of chromium metal and chromium oxide electrolytically deposited on both sides, or from aluminium. The choice between aluminium and steel cans depends on cost and customer preference. Aluminium cans are more expensive, but are preferred in certain markets. They do not have the mechanical strength of steel cans and in consequence require careful handling in the cannery. Easy open ends fitted to aluminium cans are however easier to use by the consumer.

The shape of the can could be circular or rectangular. Circular cans could be short, in which case the diameter is greater than the height, or tall, in which case the height is greater than the diameter. Short circular cans are normally of two piece construction, components being the can body and the can end. The can body is made from a disc of metal, which is then mechanically drawn into a cylindrical shape. It may be printed prior

to manufacture, or be subsequently labelled after the canning operation. Tall cans may be of two piece or three piece construction. A three piece can comprises a cylindrical can body with a welded side seam, to which is attached the maker's end. The canner's end is subsequently added after filling. A two piece tall can is generally made by a process known as DWI (drawn and wall ironing).

Cans may vary in size from approximately 85 ml capacity up to the 5 kg cans, intended for food service use. Certain types and size of cans are typically used for specific products. Sardines are invariably packed in rectangular two piece cans, pilchards in tomato sauce in 3-piece tall cans of 418 ml capacity and tuna steaks, flakes and chunks intended for domestic consumption, in short 2-piece round cans of varying capacity. The Can Manufacturers Institute (CMI) Voluntary Can and End Dimension Reference Manual is a compilation of technical information developed by committees of the CMI. Intended for use by CMI members and other interested industry representatives, this publication is available to the public as a service of the CMI.

3.9.1. Can supplier

The choice of can supplier will depend to some extent on location. If the cannery is large enough, it may be that a can maker will establish a production facility adjacent to the cannery. Certain canneries indeed have can making companies within their parent group. In selecting a can making company however, it is important that the one chosen is able to supply necessary technical support as required, particularly in relation to the closing of their containers. It is expensive to ship empty cans to very remote locations, such as Alaska. One solution is to use cans with tapered sides so that they are able to nest inside each other, which allows for packing them more densely during transportation to the cannery. They are de-nested prior to transfer to the filling line.

3.9.2. Double seam specification

It is the responsibility of the can maker to define the specification for the double seam. The integrity of the can depends on the formation of the double seam between the can body and the can end. The critical dimensions are those of AOL (actual overlap) or BHB (body hook butting), which are measures of the overlap between the body hook and the end hook, and the freespace or wrinkle grading which are measures of the tightness of the double seam. The parameters that must be routinely measured in order to determine these values include the:

- Seam length;
- Seam thickness;
- Countersink depth;
- Body hook;
- End hook;
- Overlap; and
- Seam gap.

The measurement of these parameters may be made manually using suitable micrometers, or by use of sophisticated vision machines that automatically compare a sawn cross section of a double seam with specified values. Results of the analysis are automatically stored on a computer database.

3.9.3. End compound

Can ends are supplied with a sealing compound in the curl of the end. This softens during the sterilization process and is a vital component in the establishment of a hermetic seal. Consignments of ends should be inspected at the time of arrival to check on the presence of the sealing compound.

3.9.4. Can coatings

Most fish species contain sulphide materials that will react with metal surfaces to form black compounds that would stain the product inside the can. In consequence, it is necessary to apply an organic coating to the surface of the metal that acts as a barrier between the metal and the contained food. Organic coatings may be in the form of liquid-applied coatings, polymer film laminates or polymer films, extruded directly onto the metal surface. The can maker should be able to specify the correct coating system for the products to be manufactured in the cannery.

New deliveries of cans should be visually inspected to check the apparent application of the coating system. It should be noted that European Regulation No. 1895/2005 (EC, 2005b) defines restrictions on the use of certain epoxy compounds in food contact applications. The use of BFDGE or NOGE is prohibited and typically the sum of BADGE, BADGE.H_20 and BADGE.$2H_20$ must not exceed 9 mg/6 dm^2 in containers with a capacity of less than 500 ml.

3.9.5. Aluminium cans with easy open ends

As stated above, aluminium cans are less robust than steel cans and this also applies to the easy open feature if applied to aluminium ends. Damage to the score line could cause loss of can integrity with the possible result of microbial contamination. It is therefore recommended that such cans are not allowed to tumble violently against each other, as could happen during scramble packing of a retort crate or during the subsequent unloading of a retort crate.

3.9.6. Traceability of cans

Empty cans and ends are received with labels that define the lot number of the consignment. The labels should be retained for reference and the lot numbers recorded on production records at the time of use.

Table 4. Typical can sizes - Irregular (non-round) cans

Type of can	Material	Volume ml	Length mm	Width mm	Height mm	Product	Net weight g	Fish weight g
1/4 Dingley	aluminium tin plate	112	105	76	21.5	sardines, small fish	106	85
1/4 club *	aluminium tin plate	115	105	60	29	sardines, small fish, tuna	125	95
1/2 Hansa *	aluminium tin plate	200	148	81	26	herrings	195	130
1/2 oblong	aluminium tin plate	212	154.7	61	30	kippers	225	225
1/3 oval	tin plate	200	149	81	25	mackerel	195	130
1/2 oval	tin plate	270	149	81	25	mackerel	250	180
Langoval	aluminium	190	194	58	25			

** Noblikk-Sannem A/S standards.*

Table 5. Size of 2- and 3-piece cans for different types of the most important fish products

Type of can	Material	Volume ml	Diameter mm	Height mm	Product	Net weight g	Fish weight g
Conical	TFS	418	73	110	Salmon		
Conical	TFS	213	85/83	50	Salmon		
2-piece round	aluminium	225	90	40	shrimp	217	150
2-piece round	aluminium	115	78	32	shrimp	111	75
2-piece round	TFS		65	40	tuna		
2-piece round	TFS		85	43	tuna	185	139
2-piece round	TFS		99	55	tuna		
2-piece round	TFS	126	73	34.5	salmon		
2-piece 1/2 pound round	aluminium tin plate	245	90	44	fish with vegetables, herring, tuna	230	*
2-piece 1 pound round	tin plate	490	120	49	fish with vegetables, herring, tuna	460	*
3-piece round	tin plate	212	83.8	46	tuna	200	155
3-piece round	tin plate	400	99.5	60	tuna	377	292
3-piece round	tin plate	450	72	119	cod roe in brine	425	300
3-piece round	tin plate	450	101	64	fish cakes	400	260
3-piece round	tin plate	900	101	121	fish balls	800	520
3-piece 5 kg round	tin plate	4 250	218	123	tuna, sardine	4 000	3 100
3-piece 10 kg round	tin plate	8 500	218	245	tuna	8 000	6 200

** Depends on amount of vegetables.*

3.9.7. Retort pouches

The processing of products, such as tuna, in heat sterilizable retort pouches provides advantages both for the manufacturer, for the ultimate user, and particularly for the small to medium sized manufacturer having an established labour intensive operation. Considerably less storage space is required for empty pouches compared to metal cans. Sterilization times are significantly reduced because the thickness of a pouch is less than the diameter of a can with equivalent capacity. In addition, the pouch is easier to open by the user with no risk of metal swarf contaminating the food at the time of opening, and collation and disposal of packaging is greatly simplified.

However there are also drawbacks. Specialist micro-processor controlled, overpressure sterilizing equipment is required in order to prevent pouches expanding and possibly bursting during sterilization. Special racking is required to support the pouches during sterilization and great care is needed to ensure that the pouch filling and sealing operations are carried out very carefully, and under clean and tidy conditions to ensure that sealing is effective and safe.

In short, if pouch processing is undertaken it must be done properly, with full recognition of the hazards involved, with adequate equipment, and with a quality plan aimed to eliminate the risks associated with the perceived hazards.

3.9.8. Retort pouch construction

Retort pouches for small operations are provided ready made by the pouch manufacturer. For larger capital intensive operations they may be supplied as reel fed material, in which case the pouches are formed on line immediately prior to filling.

Pouches are normally constructed of four layers of film materials held together by adhesive. Each layer has a defined function in the overall structure. The outer film is usually polyester having high heat resistance, and if the pouch is to be printed, the inks are printed onto the inside of this layer (reverse printing). Aluminium foil is used to provide the oxygen barrier providing shelf life to the contained product. A nylon layer is used to give added puncture resistance (pouches are essentially very strong, but are vulnerable to puncture by sharp objects) and polypropylene is used as the inner ply to provide the heat seal for closing the pouch.

Pouch material must meet the food contact legislation of the intended country of use of the final product. In the EU, this means compliance with the Directive 90/128/EEC (EC, 1990), and amended by Directive 2002/17/EC (EC, 2002c). There are equivalent regulations of the FDA in the USA, or the CFIA in Canada. Pouches should be supplied from their maker with a certificate of compliance with required legislation and a certificate of conformance with their own Quality Control requirements.

3.9.9. Glass jars

Small glass jars are used for certain premium products, such as tuna steaks in olive oil. Such production is suited to an essentially labour intensive artisanal factory. In using such containers, there are inherent risks of glass breakage and the factory must have adequate procedures to cope with such eventuality.

There is need for inspection of the glass containers at the time of receipt and inversion, and cleaning by water spray or compressed air prior to filling. Closure is normally by means of a metal cap with pre-formed lugs which screw into the start threads cast into the neck of the jar. It is necessary to use an overpressure retort in order to prevent the caps lifting off during sterilization and care must be taken during cooling so that the jars do not crack due to thermal shock.

3.10. QUALITY REQUIREMENTS FOR OTHER INGREDIENTS AND ADDITIVES

3.10.1. Suppliers of ingredients

In the sourcing of ingredients it is vital that the suppliers are able to provide assurance that material supplied will be of specified quality and safe for the consumer. The supplier should be able to demonstrate by virtue of certification to a standard recognized by the GFSI, or the satisfactory completion of a self-audit questionnaire, or physical audit, that their manufacturing premises are of suitable standard, that they have a comprehensive quality management system, and a fully implemented HACCP system. Specifications for all ingredients supplied should be agreed by both the supplier and the fish canning company.

3.10.2. Salt

Salt is used both during processing and as a component in the covering brine in certain styles of canned fish packs. The salt used should be pure and not contain appreciable quantities of magnesium chloride, a common contaminant of unrefined salt. If the salt contains too much magnesium chloride the risk of struvite formation is increased, particularly in canned salmon. Struvite is ammonium magnesium phosphate and in crystalline form has the appearance of small glass splinters. It is objectionable to consumers, but in reality is not dangerous.

3.10.3. Vegetable oils

Various vegetable oils are used as covering liquids in canned fish products. Codex Alimentarius Standard 33–1981 defines the compositional properties for virgin and refined olive oils, and Standard 210–1999, the properties of named vegetable oils including corn oil, rapeseed oil, soya oil and sunflower oil, all of which could be used in the preparation of canned fish. The standards include the maximum values for fatty acids and reference to the method for estimation of peroxide values.

A further concern is the knowledge of whether the oils have been made from GMO crops. Oils and fats require labelling if derived from GM plants (e.g. soybean, maize, rapeseed). This is irrespective of whether or not GM material is detectable in the final

product. Oils should be purchased to specification and delivered with certification providing evidence of their GMO status together with necessary chemical analysis.

3.10.4. Tomato paste

Tomato paste is a traditional component in covering liquids for products such as canned sardines, pilchards or mackerels. It is available in large metal cans or in typically 200 litre aseptic bags, contained in 55 gallon steel drums. Tomato paste is available in various concentrations, most typically 28/30 percent soluble solids, but also 30/32 percent or 36/38 percent. A bright red colour is an important quality attribute, but other parameters include the Bostwick viscosity, Howard mould count and pH. The Codex Standard 57–1981 provides a specification for tomato paste, and includes reference to the various recognized methods for chemical analysis.

3.10.5. Other minor ingredients

Spices may be used in the manufacture of canned fish products, either individually or in combination in a pre-blended mixture. Certain such blends may include allergen materials identified within the official EU list. It is important therefore that the canner is fully aware of the individual components in any spice or seasoning mixture used. Such materials might include: celery, mustard seeds, sesame seeds or cereals containing gluten. Full information regarding allergens and the labelling of products containing allergens is available in Directive 2003/89/EC (EC, 2003a).

4. PRODUCTS

4.1. CANNED FISH PRODUCTS

Canned fish products of traditional importance include tuna, packed as steaks, chunks or flakes in oil or brine, sardines or sardine like fishes in oil or tomato sauce, pilchards in tomato sauce, pacific salmon, mackerel in a variety of sauces including tomato, mustard and curry, fish paste products, and smaller commodity items such as shrimps, mussels or crab.

In recent years, there has been development in the range of products available. Canned salmon products are now available without skin and with the backbone removed as are skinless and boneless sardines. Spring water is used in certain products as a perceived healthier alternative to brine. Olive oil including a proportion of extra virgin oil is used as the covering liquid in certain premium products.

Recipe packs such as tuna with sweetcorn are available in small cans with easy open ends and are eminently suitable for use at lunch breaks, and canned tuna is now available with a reduced volume of covering liquid making the opening of the can more convenient and less messy for the consumer. It has also become customary to provide multipacks of canned fish products held together either by shrink-wrap film or in a cardboard sleeve.

Retort pouches are available both for the production of retail recipe packs such as Tuna with Thai Sweet Red Chilli, and also for large packs of about 2 kg for food service use, typically in the manufacture of sandwiches. It is considerably easier to open a retort pouch than a catering sized can, and there is no added risk of metal contamination. Heat sealed sterilizable semi rigid foil trays are also used for the production of recipe packs, such as Mediterranean Style Tuna Salad.

4.2. SPECIFICATION FOR CANNED FISH PRODUCTS

A canning company may be able to establish its own brand for domestic sales, but any company wishing to export would inevitably be required to pack according to the specifications and under the label of one of the major retail or trading companies. Such specifications are lengthy computer based documents and will be formally activated by the customer company.

The actual specification will depend on the availability of fish, legislation in the country of destination, and customer requirements. It will be likely to include:

- Product name;
- Fish species to be used;
- Can sizes;
- Fish presentation within the can;
- Net weight and drained weight (or pressed weight);
- Recipe information;
- Allergen information for all ingredients used;

- GMO statement;
- Flow chart of manufacturing operations;
- CCPs (critical control points) in manufacture;
- Heat sterilizing process for each size of can;
- Chemical parameters of importance (including histamine levels as appropriate);
- Nutritional information;
- Physical and sensory characteristics;
- Tolerances for physical defects;
- Microbiological information /statement of commercial sterility;
- Packaging information;
- Shelf life;
- Traceability system and end coding; and
- Labelling.

Marketing companies are keen to stress the health benefits associated with the omega–3 fatty acids naturally present in canned fish oil (omega–3 compounds are essential for human physiology and are said among other claims to improve blood circulation), and omega–3 logos appear on can labels. Retail and trading companies are also keen to stress their environmental concerns and the majority of products now claim that the fish have been obtained in a sustainable manner with endorsement from the MSC for example.

4.3. SUPPLIERS OF INGREDIENTS

In the sourcing of ingredients, it is vital that the suppliers are able to provide assurance that material supplied will be of specified quality and safe for the consumer. The supplier should be able to demonstrate by virtue of certification to a standard recognized by the GFSI, or the satisfactory completion of a self-audit questionnaire, or physical audit, that their manufacturing premises are of suitable standard, that they have a comprehensive quality management system, and a fully implemented HACCP system. Specifications for all ingredients supplied should be agreed by both the supplier and the fish canning company.

4.4. STANDARDS FOR CANNED FISH PRODUCTS

There are numerous written standards for canned fish products.

4.4.1. Codex standards

- Canned Pacific Salmon 3–1981
- Canned shrimps or prawns 37–1981
- Tuna or bonito canned in water or oil 70–1981
- Canned crab meat 90–1981
- Sardines or sardine like products 94–1981
- Mackerel or Jack Mackerel 119–1981

4.4.2. USA federal standards of identity

- Canned pacific salmon 21 CFR 161.170
- Canned tuna 21 CFR 161.190
- Canned wet pack shrimp in transparent or non-transparent containers 21 CFR 161–173

4.4.3. UK codes of standards developed between Campden BRI and representatives of the canned foods trade

- Mackerel fillets in tomato sauce — Specification L95
- Mackerel fillets in oil or brine — Specification L96
- Canned pilchards in tomato sauce — Specification L77
- Canned salmon — Specification L50
- Sardines in oil, brine or water — Specification L53
- Sardines in tomato sauce — Specification L54
- Tuna chunks in oil, brine or water — Specification L74
- Tuna flakes in oil or brine — Specification L52
- Tuna steaks in oil, brine or water — Specification L75

In general, all of these specifications define the species of fish that may be used, the acceptable minor ingredients, sampling plans, some measure of fill relative to the size of the container (pressed weight, rather than drained weight, is used for measurement of tuna within the USA), sensory characteristics, chemical parameters of importance, appropriate reference to analytical methods and labelling.

4.4.4. Tuna standard in the USA

Typically, 21 CFR 161.190 includes:

- A list of species that may be used in the preparation of canned tuna;
- Definitions of tuna solid pack, chunks, flakes and grated tuna with tolerances;
- Definitions of colour, white, light or dark and method of measurement;
- Optional packing media to include: olive oil, vegetable oil, water;
- Seasoning ingredients to include, salt, msg, hydrolysed protein, spices, spice oils or extracts, garlic;
- Specified names for tuna products and labelling requirements;
- Minimum pressed weights relative to various can sizes; and
- Method for the determination of pressed weight.

4.5. DRAINED WEIGHT DETERMINATION

In Europe, the quantity of fish is measured as drained weight rather than pressed weight. The method adopted is described in Codex Alimentarius as follows. The drained weight of all sample units shall be determined by the following procedure:

- Maintain the container at a temperature between 20 °C and 30 °C for a minimum of 12 hours prior to examination.
- Open and tilt the container to distribute the contents on a pre-weighed circular sieve, which consists of wire mesh with square openings of 2.8 mm x 2.8 mm.
- Incline the sieve at an angle of approximately 17–20° and allow the fish to drain for two minutes, measured from the time the product is poured into the sieve.
- Weigh the sieve containing the drained fish.
- The weight of drained fish is obtained by subtracting the weight of the sieve from the weight of the sieve and drained product.

5. PROCESSING

5.1. TECHNICAL OBJECTIVES

The manufacturing process involves a succession of steps from the receipt of raw materials to the dispatch of finished product. The technical objectives of processing are to obtain a shelf stable product of specified quality that is safe for the consumer, which meets all legislative requirements, and which is accomplished in the most efficient manner.

For each process step there should be a written instruction that defines precisely how the particular operation should be carried out. Employees should be trained against those specific instructions that they are required to undertake, and there should be a record of such training.

In order to achieve the technical objectives it is necessary that:

- Raw materials are of suitable quality;
- The can should be manufactured so that there is no untoward interaction between the inner surface of the can and the contained food;
- The can should be closed to provide an hermetic seal that prevents the ingress of microorganisms;
- The contents of the can should be processed to a condition of commercial sterility;
- Positive identification and separation of sterilized crates and cans from unsterilized ones;
- Cans should be cooled in such a way as to prevent post process microbial contamination; and
- All process steps should be engineered and carried out in such a manner to prevent foreign body contamination of the product.

Regardless of the type of fish to be canned there are common process steps that will form part of the overall manufacturing process. These include:

- Refrigerated raw material storage;
- Defrosting;
- Size grading;
- Fish preparation including butchering;
- Pre-cooking;
- Filling into cans;
- Preparation and filling of covering liquid;
- Coding of can ends;
- Double seaming;
- Can washing;
- Crate filling;
- Retorting;

- Cooling;
- Crate unloading; and
- Can labelling.

Picture 3. Manual preparation line in traditional sardine cannery

Picture 4. Modern Cabinplant line for preparation and packing of mackerel

5.2. FLOW DIAGRAMS

Typical flow diagrams are provided showing the process steps involved in the production of:

- Canned tuna in brine;
- Canned sardines in vegetable oil;
- Canned salmon; and
- Canned shrimps.

There are common features to all of these the differences being essentially in the manner in which the fish is prepared. Temperature control is important both in the storage of raw material and in the subsequent sterilization operations. Critical operations will always include double seaming, sterilization and the sanitation of cooling water when applied directly to cans. Tuna and sardines are normally pre-cooked whereas salmon and shrimps are not. In smaller canneries the preparative stages may be conducted manually. Machinery is available for specific operations depending on the type of fish to be processed and the size of the operation. Typical of such machinery are the nobbing machines used for the automatic removal of the head and guts of sardines.

Waste materials produced will always include fish waste, which may be used for the production of fishmeal or other by-products and water effluent, which may require treatment before discharge or possibly recycling. The manner of treatment of water effluent will very much depend on the location of the cannery and the environmental controls exercised by the local authorities.

Figure 1. Typical flow diagram for canned sardines in oil

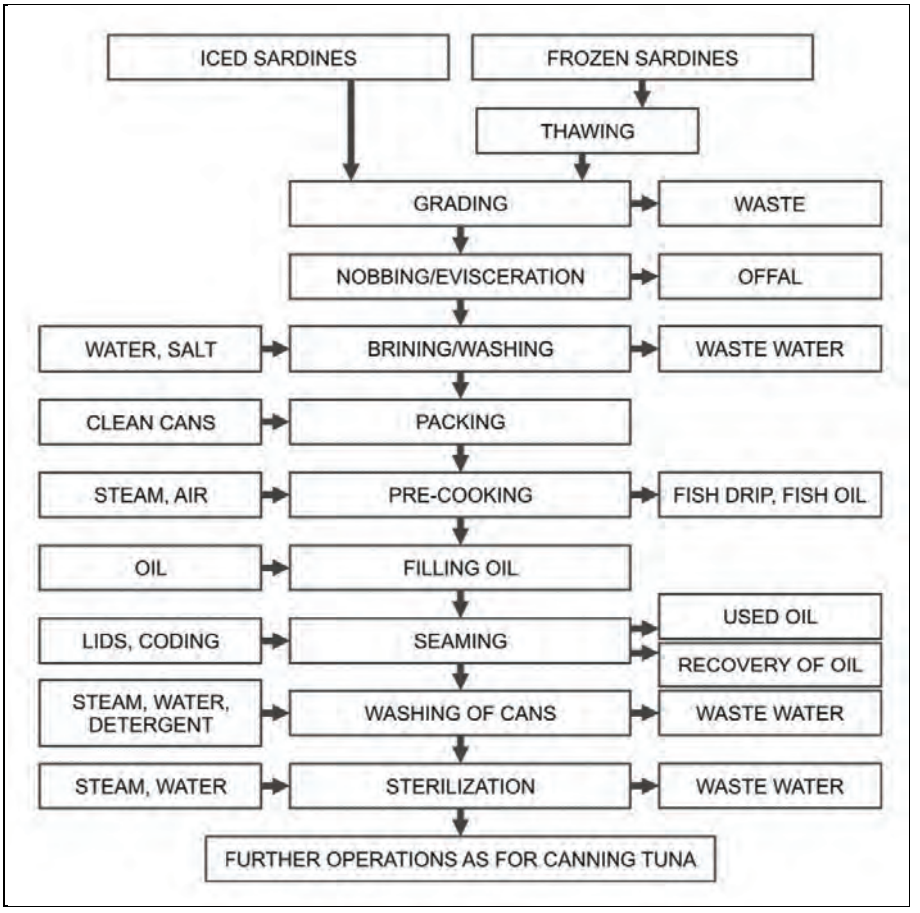


Figure 2. Typical flow diagram for pre-smoked sardines in tomato sauce

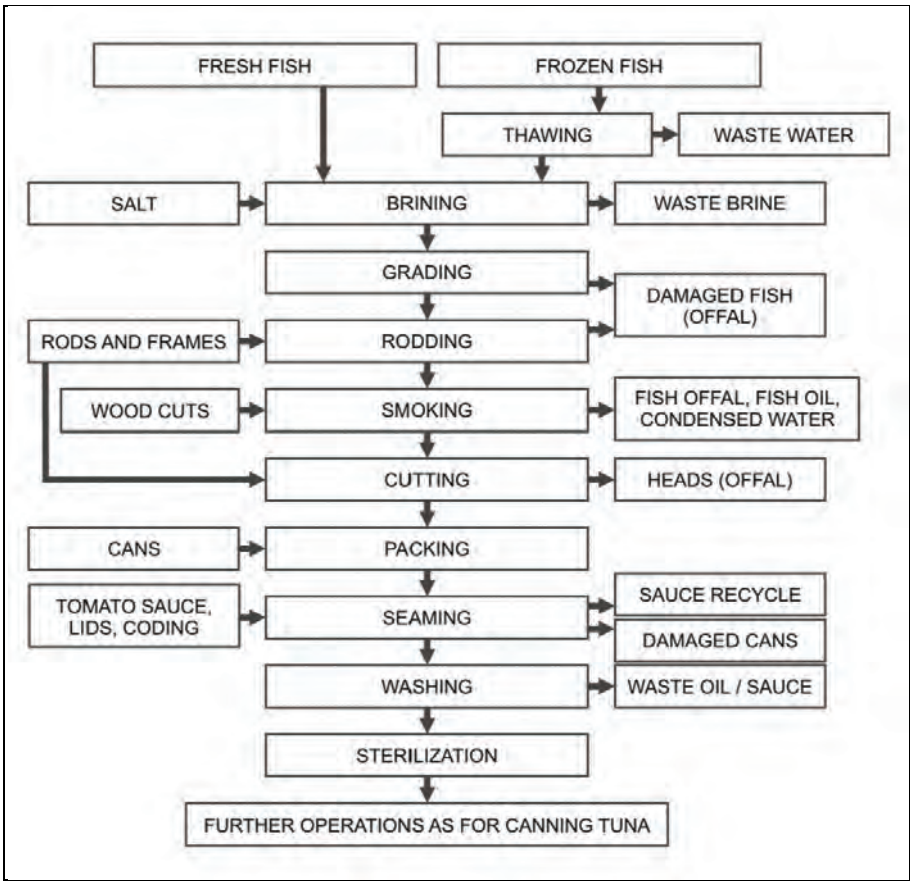


Figure 3. Typical flow diagram for fish paste

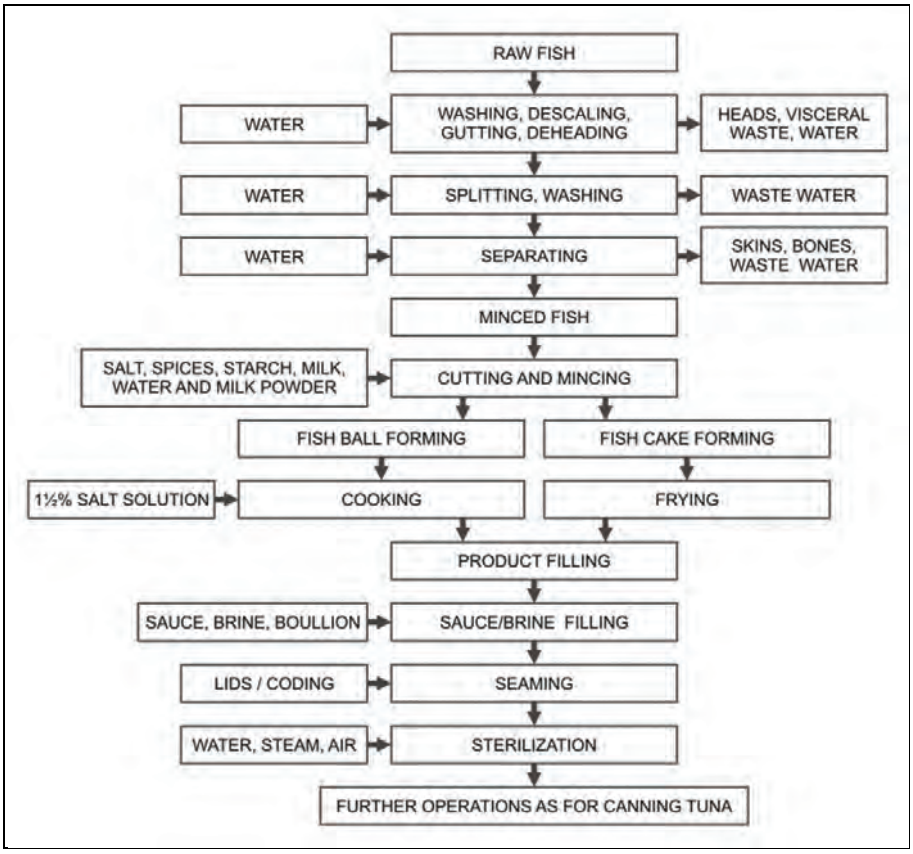
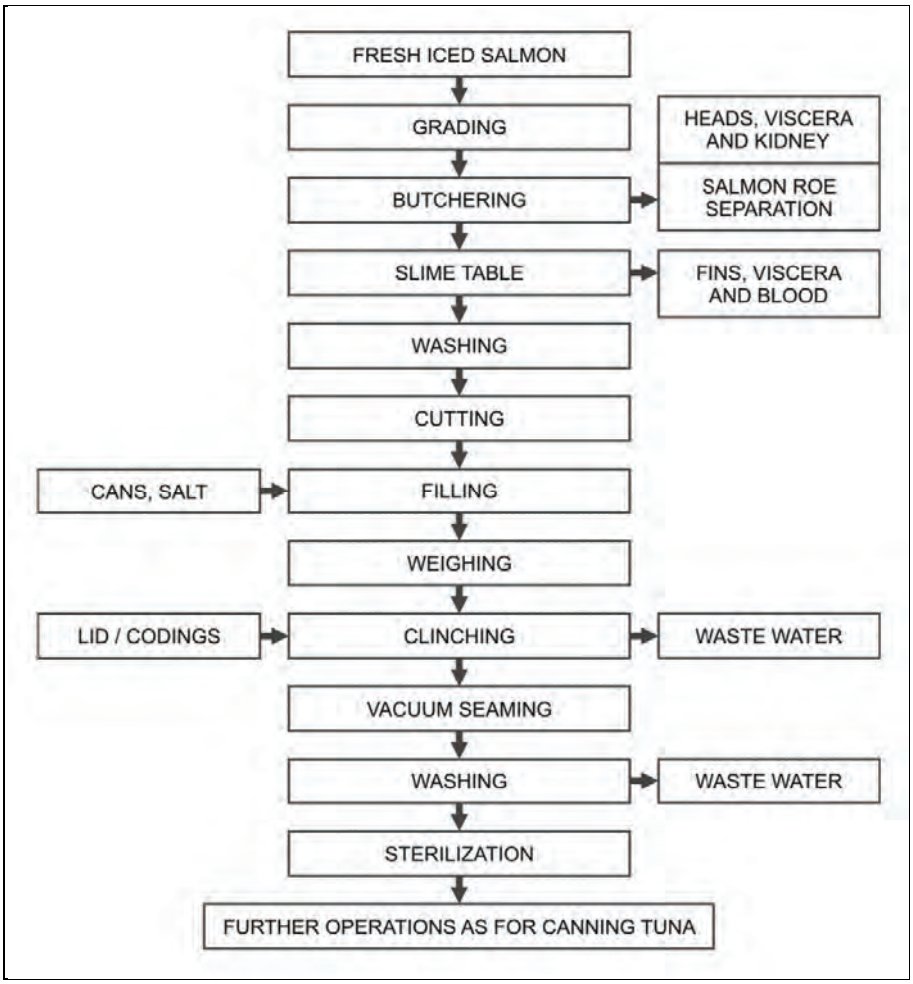


Figure 4. Typical flow diagram for canned salmon



5.3. REFRIGERATED STORAGE

It is vital that the temperature of fish is rapidly reduced after catching in order to maximize quality and to reduce deterioration due to microbial and enzymic changes, which trigger denaturation of proteins fats and dehydration. Fish from local vessels intended to be processed within one to two days of catching, should be packed with ice in boxes and delivered to the cannery in that form. The cannery will require chilled storage facility, in which to hold the fish prior to processing at a temperature maintained between -2 °C and +2 °C.

Fish that is caught during prolonged expeditions will be frozen on board and will be delivered to the cannery in frozen form. It is likely that such fish will be placed in cold

storage prior to use within the cannery. The optimum temperature for cold storage will depend on the type of fish and the length of storage, to which it is to be subjected.

The frozen storage of fish is comprehensively described by Johnston *et al* (1994). The fifteen sections include recommended storage temperatures, factors limiting storage life, and factors concerned with the design, construction and operation of cold stores. Further comprehensive information may also be obtained from James and James (2010).

The generally recommended temperature for the operation of cold stores for frozen fish is -30 °C. In the case of a fatty fish, such as mackerel, which is caught within a relatively short season and then processed during the rest of the year, such temperature is fully necessary. In the case of tuna canneries that receive frozen fish to be used within a few weeks, it is common that cold store temperatures are maintained at -15 °C to -20 °C.

Fish in refrigerated storage should be subject to proper identification, stock control and rotation. The temperatures within the cold store should be monitored and alarmed in case of deviation from specified values.

5.4. DEFROSTING

If frozen fish are to be processed they must first be defrosted. As the defrosting time will inevitably depend on the size of the fish, it is greatly preferable that the fish are size graded prior to defrosting.

The thawing process involves the elevation of temperature of the fish to 0 °C, at which temperature it may be manually cut or otherwise prepared as necessary. With tuna, it is customary that the fish are placed in large steel tanks of about 500 kg capacity, through which water is allowed to circulate for as long as necessary in order to achieve defrosting. This may be several hours in the case of large tuna. The temperature of the water should ideally not be more than 20 °C in order to reduce bacterial growth on the outer surfaces of the fish that are the first to defrost.

For smaller fish such as sardines or mackerel, commercial thawing equipment is available in which fish on racks are subjected to controlled contact with steam. Vacuum cabinets are also available, in which water in the base of a cabinet is heated under vacuum to a temperature of about 20 °C. Water vapour then condenses on the fish and the latent heat of vaporization released provides thawing to the fish. Heat transfer by this method is relatively rapid compared with simple water thawing. Large scale equipment is also available that provides for the simultaneous skin peeling and defrosting of mackerels.

5.5. BUTCHERING

With large tuna the viscera are commonly removed on board fishing vessels prior to freezing. Bonito and smaller tuna are frozen with viscera present. Once thawed, the tuna is washed and inspected for spoilage. If tuna is not eviscerated on board vessels, this must be done in the plant.

The splitting and evisceration process is normally the only butchering operation performed on the tuna while it is in the raw condition (the exception being raw pack tuna intended for sale in France). It may also be necessary to cut large tuna into suitably sized pieces by means of a band saw, for convenient loading onto racks for pre-cooking. All other cleaning is performed after the pre-cooking operation.

Salmon is traditionally filled into cans in the raw state. After grading, fish are fed into an iron chink butchering machine for the automatic removal of head, fins and viscera. Further clearing, for final removal of any remaining viscera and blood takes place manually on a sliming table. During this operation the fish is washed thoroughly, before cutting into slices and filling into cans.

5.6. PRE-COOKING

Sardines, mackerels and tuna are normally pre-cooked prior to sterilization. There are exceptions however, and particularly for the French market, tuna may be processed as" raw pack" without pre-cooking. Salmon is not normally subject to pre-cooking and is also filled raw into the cans.

The object of pre-cooking, particularly in the case of tuna, is to facilitate the removal of flesh from the carcase. The process also allows the removal of excess cook-out liquor that could adversely affect the appearance of the finished product within the can.

Typically sardines are packed into quarter club cans, which are placed in square plastic trays. The trays may hold some 4 x 7 cans each. A thin sheet of metal is placed over the tray and the whole inverted and placed on racks on a trolley which is then wheeled into a batch pre-cooker. Alternatively, modern continuous pre-cooking machinery is available. The time for pre-cooking in steam at a temperature of 105 °C is about 30 minutes depending on the size of the fish.

Sardines intended for packing as skinless and boneless products are pre-cooked directly on trays, placed on racks before cooling and subsequent manual removal of skin and bone.

The time for pre-cooking of tuna is greatly dependent on the size of fish and it is important that fish of uniform size are cooked together. The object is to attain a temperature at the backbone of about 65 °C. Cooking may typically take up to four hours to complete. Simple retorts may again be used, but very sophisticated machines are available that automatically cook to a defined backbone temperature and subsequently provide vacuum cooling. Traditional cooling of pre-cooked tuna is accomplished in a mist of cooling water and again, may take several hours.

5.7. CLEANING OF TUNA

The removal of the meat from tuna is preferably undertaken in two stages. The first operation is relatively dirty and involves the removal of the head and fins, the skinning of the fish and removal of the backbone and tail. In the second operation, the loins are prepared for filling by splitting the halves of the fish along the median line. Red meat is

removed from each loin, the blood and dark meat are scraped away and the loins, edible flakes and waste products are separated.

The proportion of flakes produced is approximately 15 percent. All such operations are labour intensive. Prepared fish may be placed in plastic trays and passed through a metal detector before transfer to the filling machinery.

There are commercially recognized standards for canned tuna depending on the size of the pieces of muscle packed. The descriptions provided in Codex 70-1981, revised 1995, are as follows:

- Tuna solid pack or steaks comprise fish cut into transverse segments, which are placed in the can with the planes of their transverse cut ends parallel to the ends of the can. The proportion of free flakes or chunks shall not exceed 18 percent of the drained weight of the container.
- Tuna chunks comprise pieces of fish, most of which have dimensions of not less than 1.2 cm in each direction, and in which the original muscle structure is retained. The proportion of pieces of flesh, of which the dimensions are less than 1.2 cm, shall not exceed 30 percent of the drained weight of the container.
- Tuna flakes comprise a mixture of particles and pieces of fish most of which have dimensions less than 1.2 cm in each direction, but in which the muscular structure of the flesh is retained. The proportion of pieces of flesh, of which the dimensions are less than 1.2 cm exceed 30 percent of the drained weight of the container.

5.8. CAN FILLING

Can filling in large tuna factories is undertaken by high speed machinery. The tuna is formed into a tube within the machine and sliced to the correct height and fill weight on presentation to the can. It is possible to adjust the amount of flake on the infeed to the machine. The tuna is always filled prior to the covering liquid, oil or brine. Smaller factories may pack tuna chunks by hand particularly if filling large cans or retort pouches intended for the food service industry.

Sardines are traditionally filled manually into cans prior to pre-cooking, but automatic machines are also available.

Mackerel are processed in both rectangular and cylindrical cans and the filling operation may take place manually or by suitable machinery according to the size of the operation. Mackerel may also be pre-cooked within the can and cooled prior to the addition of covering liquid.

Salmon from the slimming table is transferred to the filling machine, in which, with revolving knives, cut the fish into slices of the correct height and weight for presentation to the can. A salt tablet is added and cans are check weighed and adjusted manually before transfer to the seaming equipment.

Covering liquid, oil, brine or sauce is added to fish within shallow cans to overflowing. The excess liquid is screened and returned to the filling head. When the can end is

added it pushes down against the can contents and effectively excludes the air which might cause pressure development within the can during sterilization or oxidation of product. In tall cans the covering liquid may be measured into the can leaving a head space. The can may then be closed using steam flow to remove air and provide a vacuum within the can.

Picture 5. Addition of oil to quarter club cans of sardines

5.9. CAN CODING

Canned fish products have long shelf lives and it is important to maintain traceability of products, at least to the day of production and preferably to the retort cycle used in manufacture. Coding may be applied to the ends of cans by use of embossing machines, or more frequently nowadays, by the use of ink jet machines. If can ends are coded off-line, it is important that if an excess number of ends are coded, they are not used for the following production batch requiring a changed code. The manner of coding may be specified by the competent authority and will normally include a code for the factory and the Julian date.

5.10. DOUBLE SEAMING

Double seaming is one of the critical operations in the manufacture of canned fish products. The integrity of the double seam effectively provides security against the ingress of microorganisms that could cause commercial spoilage or food poisoning. The seaming process is carried out in a machine fitted with two sets of contoured rolls, first operation and second operation. The can is firmly located between a steel chuck against the can end and a base plate. During the process the can is lifted against the rolls. On high speed equipment the rolls rotate around the can. On small scale equipment the can itself may rotate against the rolls. During the first operation the body hook of the can is interlocked with the end hook of the can end. During the second operation the seam is

flattened to provide a tight hermetic seal. During the process the compound lining acts as a sealant to fill in the gaps between the five layers of metal.

Prior to seaming the can and end may pass through a clincher that provides a limited interlocking between the body and end hooks, and which ensures the correct placement of can and end when entering the double seaming machine.

As stated above, it is necessary to reduce the amount of air remaining within the can at the time of seaming or pressure may develop during subsequent sterilization due to expansion, causing stress and possible distortion to the double seam. Such air removal may be accomplished by filling to the brim as in shallow cans such as quarter club, or by steam flow closure in which steam is injected into the head space immediately before closing, or by vacuum closing as is routinely undertaken in salmon canneries.

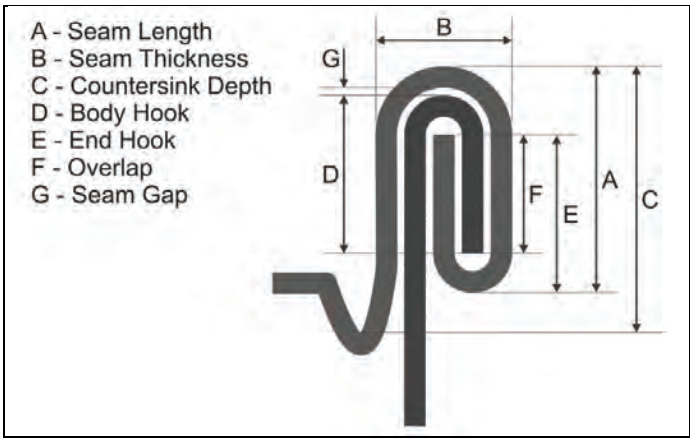
It is customary for visual inspection of sardine cans entering the infeed of a seaming machine, to ensure that pieces of fish are not overhanging the flange of the can body that could cause subsequent distortion of the seam. Such cans are also subject to tactile examination of the double seam immediately after seaming, checking for the formation of spurs or other defects.

The double seam is characterized by numerous physical dimensions that may be measured to determine the hermetic quality of the seam. They may be measured manually by use of appropriate gauges, or the cut cross section of a seam may be examined using a vision recognition machine that automatically makes comparison with the seam specification. The frequency of seam measurement will depend on the historic performance of the seaming equipment, but hourly intervals are considered normal. It is more difficult to seam rectangular cans than round cans and it is customary to measure the seam dimensions at eight points, the four corners and midway along the four sides. The seams of cylindrical cans are normally measured in three places at 60° to each other.

If a seaming machine has more than one seaming head it will be necessary to measure the necessary parameters of seams produced from each head. It is also beneficial if the seaming machine is able to automatically code the seam with the number of the seaming head used.

Seam records must be kept for a period longer than the shelf life of the product seamed and it is also customary to keep samples of the cans the seams of which have been measured.

Figure 5. Cross section of double seam



The key parameters that must be calculated are Actual Overlap (AOL) and Body Hook Butting (BHB), which are both measures of the overlap between the body hook and the end hook and the Tightness Rating.

The AOL describes the overlap of the end hook and body hook within a double seam. Percentage overlap may also be used.

$$AOL = E + D + 1.1Te - A$$ Where Te = End plate thickness

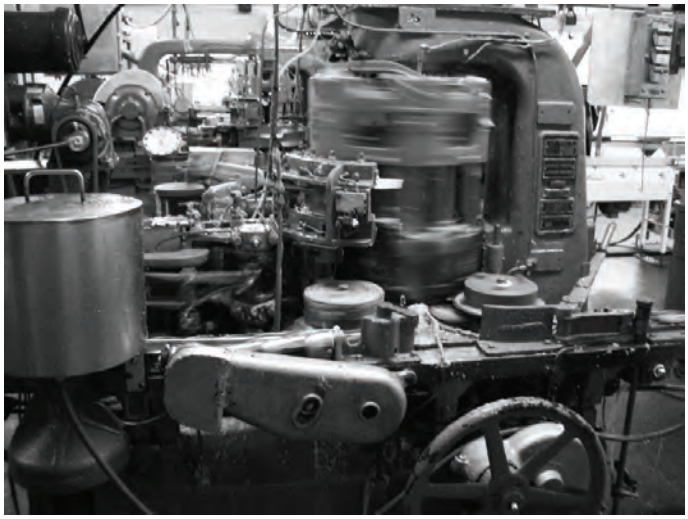
BHB is a parameter describing the relationship of the body hook to the internal seam length. It gives an indication of how much the Body Hook is imbedded into the compound of the primary seal area of the double seam. It is expressed as a percent with a minimum value of 70 percent.

$$BHB = \frac{D-1.1Tb}{A-1.1(2Te-Tb)} \text{x}100$$ Where Tb = body plate thickness and Te= end plate thickness

The Wrinkle Grading describes that portion of the end hook that is affected by wrinkle as a percentage of the end hook length. This is the inverse of the Tightness Rating.

The Tightness Rating is the unwrinkled percentage portion of the end hook below the worst point on the torn down end hook.

Picture 6. Vacuum seaming machine in salmon canning factory in Alaska



5.11. CRATE LOADING

After double seaming, cans may pass through a washing machine prior to loading into steel crates in which they will be sterilized. Depending on the type of retort, the sides of the crates may be perforated to allow the free passage of the heat transfer medium, steam or superheated water, or solid as in the case of raining water retorts. In the latter case, the base of the crate is perforated to allow the flow of water within the crate from top to bottom.

Cans are generally positioned in horizontal layers separated by plastic perforated layer pads. In small canneries they may be filled manually, but machine loading is normal. The layers are supported on a vertical ram that is lowered as each layer is filled.

Cans may also be scramble packed, in which case the crate is positioned in a tank of water and the cans allowed to tumble into the crate until full. The water provides cushioning and prevents physical deformation of the cans during the process. The crate is then lifted out of the water and allowed to drain before transfer to the retort. It is necessary to check that the temperature distribution is satisfactorily uniform within the retort. It is important therefore that temperature distribution testing is carried out, using the exact configuration of cans and layer pads that will be used in practice.

When two piece cans such as quarter club are scramble packed it is possible that numbers of cans may nest securely together. In consequence, a larger can is produced whose height is longer than the diameter. When carrying out thermal process evaluation testing, it is necessary that the tests are undertaken with a nested stack of cans. In the case of quarter club cans, it would be normal to position the thermocouple measuring temperature during processing at the centre of a stack of five cans.

5.12. RETORTS

The retorting process in which cans are sterilized is perhaps the most critical operation in the manufacture of canned fish products. Retorts are available in varying degrees of configuration and sophistication. Traditional retorts are either vertical or horizontal vessels in which crates of cans are sterilized in saturated steam. More modern equipment is invariably horizontal and fully microprocessor controlled, allowing the independent control of both temperature and pressure. The heat transfer medium may be a mixture of steam and air or superheated water. There are advantages and disadvantages to all types of machine.

5.12.1. The retort cycle

The retort cycle consists of a number of defined steps. Crates of cans are loaded into an empty retort and the vessel closed. There is a come-up phase, in which the retort is brought to sterilizing temperature (venting to remove air present is required with saturated steam retorts). Come-up is followed by the sterilizing phase, during which, the retort is held at a uniform programmed temperature and finally cooling and unloading. Cans should be cooled to a temperature of about 40 °C at which temperature there is sufficient heat to facilitate drying of the cans.

It is vitally important that sterilized cans may be fully identified in comparison to unsterilized cans. This may be affected by the use of heat sensitive labels or tape, by heat sensitive ink used in the coding of can ends which changes colour during processing, and importantly by the organization of the retorting and post process areas. It should not be physically possible to transfer crates of unsterilized cans to the post process area.

5.12.2. Saturated steam retorts

The simplest form of retort comprises a steel pressure vessel, in which cans are heated in an atmosphere of saturated steam. They may be horizontal or vertical in configuration and sized to take a certain number of crates of cans. If the retorts are vertical, there is a requirement for a mechanical hoisting system for load and unloading of the crates. The advantages of saturated steam retorts are:

- Relatively simple machines and consequently inexpensive;
- Operate at low pressure, typically 0.7–1.4 bar;
- One variable control, i.e. temperature, capable of manual operation;
- Versatile, may be used for numerous products and can sizes;
- Steam is a very effective heat transfer medium. As steam condenses it releases latent heat of vaporization.

The disadvantages, however, are:

- Saturated steam retorts require venting to remove any air present in the retort; and
- There is no way to independently control pressure so that the retorts are more liable to cause deformation of cans (peaking or panelling). and they are unsuitable for processing alternative forms of packaging such as retort pouches or heat sterilizable plastic containers.

5.12.3. Venting of saturated steam retorts

The temperature of saturated steam is directly proportional to pressure. If the temperature changes, then so does the pressure. Typically the operating temperature of a retort at 121 °C corresponds to a gauge pressure of one bar. The total pressure within a retort is the sum of air pressure and steam pressure. The total pressure in the retort is constant at 1 bar. If in a localized area of a retort, there is residual air corresponding to 0.3 bar pressure then the steam pressure must be 0.7 bar. This steam pressure corresponds to a temperature of 115.4 °C. Consequently, in this location there is a likelihood that cans could be under-sterilized.

Saturated steam retorts are fitted with a vent pipe, drain, steam control valve and control valve bypass. At the start of the venting process, both drain and vent valve are fully open. Steam is introduced fully with the bypass open until the temperature of the retort reaches 100 °C when the drain is closed. Steam is then allowed to blow hard through the vent pipe for a period of time, determined during temperature distribution studies, until all air is considered to be expelled. The vent valve is then closed and the steam supply reduced by closing the bypass valve and allowing temperature to be controlled by the temperature controller.

5.12.4. Overpressure batch retorts

These are retorts manufactured in stainless steel with full microprocessor control allowing independent programming of both temperature and pressure throughout the entire retort cycle. There are two principle types; those in which the heat transfer medium to the cans is superheated water and those in which a mixture of steam and air is used. The boiling point of water under atmospheric pressure is 100°. By increasing the pressure it is possible to maintain water in the liquid phase and use it as a heat transfer medium within a retort.

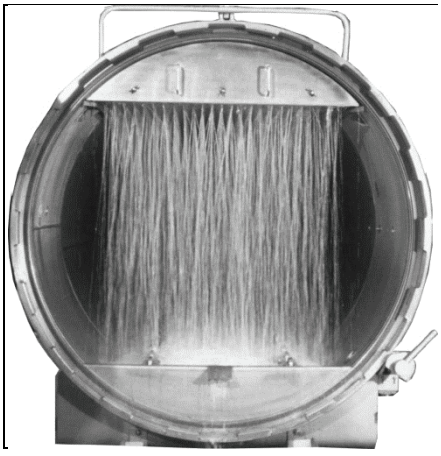
Superheated water retorts are designed so that cans are fully immersed in water or in which a relatively small amount of water originally in the base of the retort is used. In the latter case, the water is circulated through an external heat exchanger and is then returned either through a shower head so that water falls vertically through the crates, or through spray nozzles positioned along the length of the retort. Steam and cold water are applied in turn to the external heat exchanger so that the circulating water is initially heated up during sterilization and then cooled down during cooling. The advantage is that the water in contact with the cans is itself sterilized, and does not require further chlorination. It is important however that the logic within the microprocessor does not allow top up water to be added to the retort during the cooling phase.

In the raining water style of retort, at the start of the process, the recirculating water will drop slightly in temperature as it falls through the cans within the retort. It is customary therefore to include an overshoot of temperature of about three degrees for the first five minutes of the sterilizing phase of the thermal process.

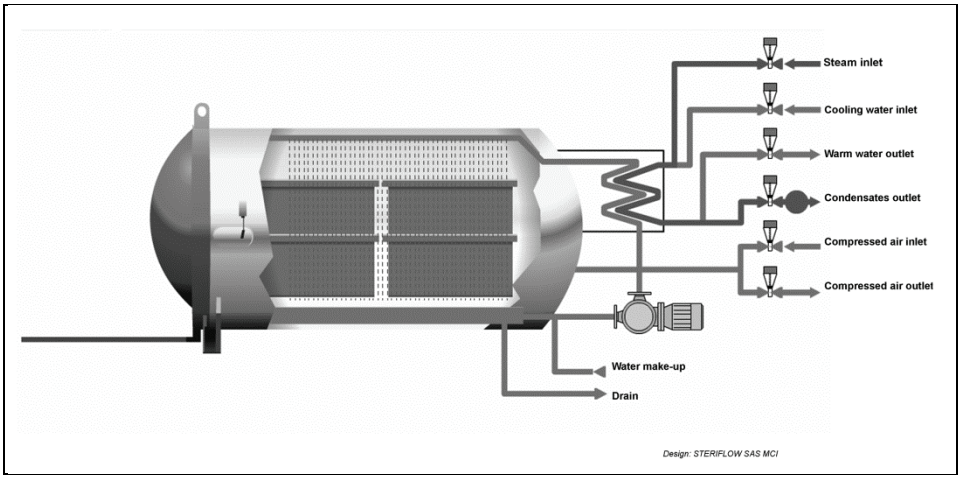
Steam/Air retorts are different in that the temperature within the retort is controlled by the introduction of steam, and pressure is controlled by the introduction of compressed air. The gaseous mixture is made uniform in composition throughout the retort by a large electric fan fitted to the rear of the retort. The steam/air mixture flows horizontally through the body of cans and returns to the fan via baffles situated along the inner sides of the retort. Steam/Air retorts, because of the horizontal flow of gas, are eminently suitable for processing of retort pouches that lay flat on specially designed trays during sterilization. An important check in the operation of steam/air retorts is to ensure that the fan is fully working, otherwise localized under sterilization could occur.

Full immersion water retorts are constructed with two chambers. The upper chamber is effectively a boiler and contains superheated water. At the start of the thermal process this water is dropped rapidly onto the cans in the lower vessel. The come up time is consequently rapid and temperature is subsequently controlled by the introduction of steam. Pressure is controlled by the application of air pressure to the top vessel. At the end of the sterilizing cycle, cold water is introduced to the lower vessel forcing hot water back to the top boiler. Hence there is a degree of energy conservation. In certain full immersion water retorts, the crates of cans rotate inside the lower vessel. This assists in heat transfer with products that heat by forced convection, but is unlikely to be of benefit to canned fish products in which the majority of heat transfer is by conduction.

Picture 7. Flow pattern inside a Steriflow cascading retort



Picture 8. Schematic diagram showing mode of operation of Steriflow cascading retort system



5.12.5. Cooling water

If cold water is introduced into the retort to provide cooling by direct contact with cans it must be sanitized in order to minimize any risk of leaker infection. Cooling water is most frequently sanitized by the introduction of chlorine, which is dosed into the water by the addition of sodium hypochlorite solution or chlorine gas to an initial level of about 5ppm. A contact time of at least 20 minutes is necessary to ensure sanitation of the water and the final requirement is that there should be free residual chlorine present in the cooling water at the point of discharge from the retort. The level of free residual chlorine is most conveniently measured by the use of DPD reagent. A pink colour is produced the intensity of which may be measured using a comparator and which is proportional to the concentration.

Cans are wet immediately after processing and the compound in the double seam is not fully set. As such they may be liable to post process infection. It is important that cans are not manually handled until they are cool and dry. A dedicated area with restricted access should be provided for this purpose.

It is also vitally important that sterilized cans may be fully identified in comparison to unsterilized cans. This may be affected by the use of heat sensitive labels or tape, by heat sensitive ink that changes colour and by the organization of the retorting and post process areas.

6. HACCP

6.1. INTRODUCTION

HACCP (Hazard Analysis Critical Control Point) has become the accepted management technique for food processing companies in the assurance of product safety. It is a practical requirement that all fish canneries will have an HACCP system and such systems are subject to inspection and approval by the local competent authority, typically the Veterinary Department or Standards Bureau. The European regulation 852/2004 (EC, 2004a), requires that food manufacturing companies implement and maintain a procedure based on HACCP principles.

6.2. HACCP STANDARDS

Detailed explanations of the HACCP system and the manner in which companies may develop their HACCP plans are provided in Codex Alimentarius (CAC, 1969) and Campden BRI (2009). In 2005, the International Standards Organization (ISO) published ISO 22000:2005, which is an auditable standard combining Quality System Management and HACCP principles (ISO, 2005).

6.3. RISK ANALYSIS

Essentially, the company is required to examine each step of the manufacturing process in turn and to consider the associated physical, chemical and biological risks that could be of significant concern for food safety. Such analysis should be conducted by a team of people having appropriate theoretical and practical knowledge. In the case of small companies, it may be necessary to also contract external expertise as necessary.

6.4. DETERMINATION OF CCPS

Having determined the likely risks, a standard decision tree is used to determine the CCPs (Critical Control Points). A CCP is defined in Codex Alimentarius as a process step, at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. In practice, there should be a relatively small number of CCPs and this allows management efforts to be concentrated on the matters of most importance in the assurance of food safety. To be identified as a CCP there must be control applied at the process step which is operative in real time and which may be monitored at specified intervals. There are CCPs which are generic in the production of canned fish:

- Double seaming;
- Sterilization;
- Sanitation of cooling water in direct contact with sterilized cans; and
- Metal detection may also be listed as a CCP if implemented in practice.

6.5. THE HACCP PLAN

For each CCP it is necessary to determine and specify:

- The Critical Limits for each control measure;
- The Monitoring System that will confirm that control is within acceptable limits;
- The Corrective Action Plan in case the monitoring system indicates that the control of a CCP has been lost;
- The Verification System that is used to check that the HACCP system is being properly applied in practice;
- The Documentation System that includes all written procedures and record forms used in the application of the HACCP system;
- The HACCP plan including all of these requirements is usually presented in tabular form. One element from a typical table is shown below.

Table 6. Section of a typical HACCP plan

CCP No.	3
Process step	Sterilization. Correct thermal process selected from schedule SC1.
Monitoring	Automatic chart recorder for temperature and pressure. Cross reference of mercury thermometer with chart recorder twice each batch. Manual completion of retort log sheet for each batch.
Critical limits	Measured temperature within -½ to +1 °C of scheduled value. Process time within -½ to +1minute of scheduled value.
Corrective actions	In case of possible under-sterilization: Inform Thermal Process Manager. HOLD suspect batch. Use mathematical modelling programme to assess status. Carry out incubation testing. Re-process if necessary. **Thermal Process Manager makes final decision.**
Verification	All process records verified daily by thermal process manager. Incubation testing at 37 and 55 °C. **Internal audit of CCP 3 at 3-monthly intervals.**
Documentation	Thermal Process Schedule SC1. Retort Operating Procedure including Corrective Action Procedure. PRO RT1. Retort operator's log sheet RO1. **Non-Conformance report sheet NC1.**

6.6. TRAINING

It is vital that all factory personnel are aware that there is a HACCP system in operation and all personnel engaged in CCP related activities must be trained against the documented procedures relevant to the CCP for which they are responsible. Training records showing the trainee, the date of training, the trainer and the procedure(s) against which training was provided should be permanently maintained.

6.7. PREREQUISITE MEASURES

Apart from the CCPs the HACCP system also recognizes pre-requisite measures. These are the general matters that provide the operational and environmental conditions within the factory that facilitate the production of safe food. They are common to all products and include such matters as: Factory Maintenance, Personal Hygiene Regulations, Cleaning and Sanitation, Preventive Maintenance, Pest Control, Waste Removal, Supplier Approval and Control, Product Traceability and Recall Procedure, Internal Audits, Product Specifications and so on. If a hazard is controlled by a pre-requisite measure it may not be nominated as a CCP.

6.8. HACCP REVIEW

The HACCP team should meet at least annually to review the HACCP system and at intermediate intervals whenever there is a change to the products or processes deployed in the factory and whenever the verification activities indicate that the HACCP system is failing in some way. All meetings should be minuted and records maintained. Verification activities could typically include:

- The review of all records of manufacturing and monitoring activities;
- Internal audit of the HACCP system;
- Review of customer complaints;
- Recommendations of third part audits;
- Servicing and calibration of critical instruments; and
- Incubation testing.

7. BY-PRODUCTS

In fish canneries, the offal from the preparatory stages is available for the production of by-products, principally canned and frozen pet food, minced frozen fish and fish silage for animal feeding, fish meal for use as fertilizer or in aquaculture, and fish oil. Large factories may have their own plant for further processing, but it is normal for smaller operators to provide waste material to specialist companies.

The brown meat from tuna canning operations is commonly used in large factories for the production of pet food. Salmon canneries are able to enjoy the profitable sale of salmon eggs.

Oil recovered from the canning process should only be used for industrial purposes. The greatest tonnage of fish offal is used in the production of fish meal and fish oil. The fundamental considerations and the processes employed in such manufacture are described in the FAO Corporate Document: "The production of fish meal and oil". Fish waste is essentially composed of three fractions, fat-free dry matter solids, water and oil. During processing, it is necessary to separate these components in the most efficient manner, as economically as possible, and under conditions specified to produce the best possible products.

The quality of by-products depends on the freshness of raw material and their fat content and nutritional value. It would be normal for fish waste to be collected for further processing on the day of production. Fish flesh is generally more valued than viscera, heads and backbones. The source and approximate yields of by-products from various fish canning operations are shown in the following table.

Table 7. By-products

By-product	By-product yield from canning operations		
	Tuna (percent)	Sardines (percent)	Salmon (percent)
Pet food	4–6	--	--
Fish meal	30–35	20–30	30–35
Industrial oil	< 5	5	--

8. PACKAGING AND STORAGE

8.1. PACKAGING

Cans may be fully lithographed (in particular those flat cans such as quarter club, Dingley or Hansa), may be plain and packed in printed cartons, or may be labelled with paper labels.

Cans when produced may be intended for defined customers and made to individual specifications, or may be standard products suitable for distribution to general trade. In the latter case, non-lithographed cans may be packed bright for subsequent labelling with the customer's own labels. Such labelling is normally undertaken using automatic machinery, but where labour is available and relatively cheap, may be carried out manually.

As part of the final packing operation, additional coding may be applied to each can for traceability purposes to include, for example, the individual retort batch or production line used in manufacture.

Cans are packed into individual cartons either manually or by machine, depending on the size of the operation and the availability of labour.

Cans are finally packed into cardboard cases or are shrink-wrapped onto cardboard trays. The shrink wrap material should not seal the trays completely, as this will prevent air circulation which may cause moisture to be trapped and corrosion of the tin plate.

8.2. LABELLING

Individual containers and outer cases must be suitably labeled. Such labelling must meet the legislative requirements of the intended country of destination. Within Europe for example, food labelling is essentially described in Council Directive 2000/13/EC (EC, 2000), which consolidated an earlier and often amended Directive 79/112/EC on the labelling, presentation and advertising of foodstuffs (EC, 1979). In addition, the labelling of allergen materials is described in council Directive 2003/89/EC (EC, 2003a). Labelling should as a minimum contain as described below.

8.2.1. The name of the food

The name shall indicate the true nature of the food and normally be specific and not generic. In certain cases the name may be prescribed within EU legislation, such as the case for sardines.

8.2.2. List of ingredients

A complete list of ingredients shall be declared on the label in descending order of proportion. In certain cases, generic names may be listed in order to simplify the label.

8.2.3. Net contents

The net contents shall be declared in either the metric or avoirdupois systems of measurement, or both, as required by the country of intended destination. Within Europe there are also rules of Quantitative Ingredient Declaration (QUID). For example if the name of the product is sardines in tomato sauce there should be indication of the percentage quantity of sardines in the product. QUID requirements do not apply however, if both net drained weight and net weight of the contents of the can are provided.

8.2.4. Date marking

Canned products with a shelf life of more than 18 months are required to carry a “best before” date as an indication of durability. The exactness of such terminology may be to the end of the specific year, for example “best before end 2012”.

8.2.5. Name and address

The name and address of the manufacturer, packer, distributor, importer, exporter or vendor of the food shall be declared. It should be noted that foreign facilities, which manufacture food products for sale for human consumption in the USA, must be registered with the FDA.

8.2.6. Country of origin

The country of origin of the food shall be declared if its omission would mislead or deceive the consumer.

8.2.7. Optional labelling

Any information or pictorial device may be displayed on labelling provided that it would not mislead or deceive the consumer in any way whatsoever in respect of the food. Within Europe the provision of nutritional labelling is optional, unless a specific nutritional or health claim is made.

Labels may carry the logos of food assurance schemes, such as that of the MSC, provided that the company has been suitably audited and has a current certificate of conformance with the MSC standards.

8.2.8. Grade designations

If grade designations are used, they should be readily understandable and not be misleading or deceptive in any way.

8.3. STORAGE OF FINISHED PRODUCTS

The manner of post sterilization packaging and storage will inevitably depend on the size of the factory, the extent of mechanization, and the availability of labour.

8.4. POST PROCESS WASHING

Post process washing is not recommended for risk of leaker infection. (Certain major trading organizations specifically forbid this practice in their specifications). The need for post process washing is eliminated by the use of effective washing of cans after the seaming operation, by the use of retorts made from stainless steel rather than mild steel prone to rusting, and by the use of clean cooling water. If post process washing is found to be necessary, the cans should be fully cooled from sterilization, before washing in clean water at a temperature in excess of 75 °C.

Manual unloading of wet cans from retort baskets is not recommended again for risk of post process contamination from the operator's hands. On removal from the retort, baskets of cans should be tilted to allow drainage from the countersinks of the can ends and then allowed to cool and dry thoroughly before any attempt is made to remove them by hand.

Cans may be stored in temporary cases in the warehouse prior to final inspection, labelling and final packing prior to despatch. The competent authority in the country of manufacture may require that cans are only exported until the completion of official analysis.

8.5. INCUBATION TESTING

Incubation testing may provide valuable information must never be used as the sole criterion of assessing the safety of heat sterilized products. Small scale laboratory incubation may detect gross under sterilization, but is unlikely to detect low levels of leaker spoilage caused by seam defects for example. (If the true rate of failure is 1 in 1000 it would be necessary to test 3000 samples to be 95 percent certain of detection). Typically the conditions used for incubation testing are 37 °C for ten days in checking for under sterilization, and 55 °C for the detection of thermophilic organisms as a measure of general sanitation. Guidelines on incubation testing of ambient shelf stable heat preserved foods are described in Campden BRI Guideline No. 34.

8.6. FINAL STORAGE

The final storage of canned products should be in a warehouse having dry conditions and with good air ventilation. The temperature of storage should not be in excess of 40 °C, nor at freezing temperatures. Ideally in order to prevent excessive condensation and possible resultant corrosion, the daily variation in warehouse temperatures should not exceed 5–8 °C.

Canned fish products manufactured and stored under normal conditions usually have a shelf life of at least two years. The size of the warehouse will depend on the type of commodity and the seasonal nature of production. Tuna canneries for example, operate

year round, whereas salmon canneries in Alaska operate solely for e a few weeks of the summer season.

Ideally the warehouse would be fitted with a racking system, but if this is not available, three to four pallets of finished product may be stacked without damaging the cans (this may not be possible with aluminium cans however). Typically a pallet may contain some 800 kg of finished product including packaging.

8.7. STORAGE OF INGREDIENTS

In general, ingredients should be stored in a clean, dry and preferably cool place. Tomato paste in cans or drums may be stored however in less controlled conditions. Dry commodities including starch, spices, salt and dried vegetables are also able to withstand variable storage conditions, as are vegetable oils in drums or external tanks. Care must be taken if minor ingredients include allergen materials, that they are stored in such a manner as to reduce any risk of cross contamination.

9. REQUIREMENTS FOR FACTORY CONSTRUCTION

9.1. GENERAL CONSIDERATIONS

The factory is intended to provide a suitable environment in which processing operations may be carried out for the manufacture of food that is safe for the consumer, and which provides a safe working environment for all employees. The factory should be designed so that it minimizes any risk of contamination to the food, from either the fabric of construction, or from the personnel working in it.

In the siting of the factory it is necessary to consider the availability of fish supply, availability of empty cans, availability of labour, transport routes for delivery of materials and export of product, the reliability of public services; such as electricity, the sources of water and the means for waste disposal.

It is also necessary that the site is secure from theft or malicious contamination. More recently, concerns have been raised that food factories could become targets for bio terrorism and companies exporting to the United States are required to provide evidence of their security arrangements.

9.2. AREAS OF THE FACTORY

The common areas required in factory construction are:

- Entrance facilities for personnel to include toilet accommodation, locker and changing rooms, hand washing facilities;
- Canteen facilities;
- Raw material receipt area with possible requirement for frozen or chilled storage;
- Warehousing for ingredient materials;
- Area for initial butchering/essentially dirty operations;
- Pre-cooking area with cooling as necessary;
- Main preparation area according to type of fish to be processed;
- Empty can storage area and can loft for feeding empty cans to filling line;
- Sauce/brine preparation area;
- Can seaming area;
- Retort area (organized to ensure differentiation between unprocessed and processed cans);
- Post process cooling area;
- Final labelling and packing area;
- Warehousing for finished products;
- Laboratory;
- Engineering workshop; and
- Effluent plant.

9.3. CONSTRUCTION

Buildings for fish canning operations are subject to internal conditions of use which, in many respects, would lead to rapid decay of building components unless special precautions are taken in their selection.

The various types of processing rooms will pose different requirements regarding insulation, surface finish, bearing capacity of floors, resistance to intensive high-pressure, hot water cleaning, resistance to chemical and mechanical wear, and so on. Great care has, therefore, to be taken in choosing proper building materials and detailed design for fish processing buildings.

Canneries should be planned in detail with considerable emphasis on the hygienic aspect, sanitary facilities and control. The 2011 BRC Global Standard for Food Safety Issue 6, section 4.4, describes numerous references to requirements of building fabric including, walls, floors, drainage, ceilings and overheads, doors, lighting, and ventilation.

Floors should be hard-surfaced, waterproof, non-toxic, non-absorbent, easy to clean, and maintained in good condition. Preferably they should be constructed of reinforced concrete, coated with anti-slip treated 1–4 mm slurry epoxy or acryl epoxy resin. Heavy duty ceramic tiles may also be used. Drainage gullies should be positioned relative to the machines that are involved in wet processing and the slope of the floor should be at approximately 1 in 60 towards the drains. The height in processing rooms should be 4 m. Column and main beams should be made of reinforced concrete with smooth surface.

Walls are important for providing separation of areas of the factory requiring different operational conditions. Walls should be smooth, waterproof, resistant to fracture, light coloured and readily cleanable. The EC Regulation 852/2004 (EC, 2004a) requires that "wall surfaces are to be maintained in a sound condition, and be easy to clean and, where necessary, to disinfect. This will require the use of impervious, non-absorbent, washable and non-toxic materials and require a smooth surface up to a height appropriate for the operations". The choice of surface coating includes specialized epoxy or polyurethane paints, composite panels, ceramic tiles and cladding materials that are attached as sheets to the walls.

Wall to wall and wall to floor junctions should be coved or rounded to facilitate cleaning. Ceilings and overhead structures should be constructed so that they impose no risk of contamination to the food processing operations below.

Doors to the factory should be close fitting and provide proofing against the ingress of pests or other forms of contamination. If doors are required to remain open they should be further protected by the use of plastic curtains or air curtains. As required they should be large enough to allow the passage of fork lift trucks.

Windows should be made from, plastic materials, toughened glass or glass protected from splintering by the application of plastic film. Glass is a hazardous material within

the factory, and should be avoided wherever possible. In the same context, all light fittings should be suitably protected from breakage.

9.4. WATER SUPPLY AND DRAINAGE

Water is used in a fish canning factory for a number of applications, some of which include food contact. If the cannery has different sources of water having different qualities of composition, and which are used for different applications, it is advisable (indeed it may be obligatory) that the supply pipelines are colour coded so that they are not used for the wrong purpose. Typically mains water may be used for spray cooling of pre-cooked tuna, while well water may be used for lesser applications, such as floor cleaning. Acceptable quality for drinking water in terms of chemical, microbiological and sensory parameters is described in the EU Drinking Water Directive 98/83/EC (EC, 1998).

Drainage and the treatment of effluent and waste materials is an important feature for fish canneries. There may be extensive local environmental regulations in force that must be met. Water effluent plants are expensive to install, require considerable areas of ground and continuous control of operation. Initial screening to remove coarse solids is an essential procedure regardless of further treatments (0.5–0.75 mm openings). Both vibratory and rotating screens can be provided.

Sewage from toilets should be connected to the municipal system if possible. If not, it should pass to a septic tank.

A large amount of fish waste is generated within the cannery and ideally a fish meal plant should be available locally in order to reduce transport costs.

Table 8. Typical requirements of floor area in square metres required for certain types of factories

Product	Capacity tonnes/8hrs	Pre-treatment	Pre-cooking	Packing	Filling seaming	Sterilization labelling
Tuna in brine	20	225	190	400	275	350
Automatic skipjack production line	10		350	400	300	250
Sardines in oil	15	600	200	400	200	250
Pre-smoked small fish	5	110	90	180	80	120
Fish paste product	10	120	130	30	70	150
Salmon	8	150	-	60	60	120
Shrimp	3.6	130	35	30	40	110

Comprehensive details regarding the materials for use in the construction of food processing factories (in particular floors, walls, ceilings and services) may be found in Guidelines 39, 40 and 41 published by Campden BRI.

10. QUALITY MANAGEMENT SYSTEM

10.1. MANAGEMENT COMMITMENT

The objective of the fish canning company is to provide products which are safe for the consumers, comply with all legal requirements, and which meet customer specifications for quality. In order to achieve these objectives it is necessary that the company develops, implements and maintains a Quality Management System. For the system to be effective, it is vital that there is full commitment from the senior management of the company to provide the necessary financial and human resources for its operation.

10.2. DOCUMENTED SYSTEM

The Quality Management System is effectively a set of documents that describe completely all the operations undertaken by the company in the manufacture of their products. There are three layers of documents. At the top level are the policy statements such as the Food Safety and Quality Policy, the Environmental Policy or the Allergens Policy, which are statements of intent. All personnel within the factory should be made aware of the policy statements and these should be permanently posted on relevant notice boards. The middle tier of documents are the general procedures that describe how food safety and quality objectives are met and include such as the Traceability Procedure, the Pest Control Procedure or the Recall Procedure. The documented policies and procedures should be collated in the form of a Quality Manual. Finally there are the work instructions that define in detail how the factory processes, such as the operation of a seaming machine or retort should take place. Such instructions may also include reference to the machine manufacturer's handbooks.

It is vital that operators in charge of machines should have been trained against the specific work instruction for that machine and that such training is recorded. The three primary layers of documents are further supported by supplementary documents such as record forms used in relation to manufacturing or test operations and product specifications. Specifications for finished products are often required in the format of the customer.

There should be a Document Control Procedure that defines how system documents may be initiated, distributed to relevant personnel, and changed if necessary. There should be a list of all system documents and all documents should be individually identifiable by reference number. The document control system should be administered by the Quality Assurance Manager. If the controlled document system is computer based, there must be adequate back up in case of computer failure.

In practice, it is necessary that operations within the factory are undertaken in accordance with the relevant procedures or work instructions and that there is evidence to prove that such is the case. Operator's log sheets and temperature recorder charts for instance, provide evidence of the correct operation of retorts. The period of retention of production and test records should be defined and must be in excess of the shelf life of the products.

10.3. ORGANIZATION OF PERSONNEL

The organizational structure of the company should be clearly defined with identified responsibilities and lines of command. Job descriptions should be available at all levels and should define exactly who has the primary responsibility for food safety within the company.

In order to monitor the correct application of the quality management system, it is necessary that a programme of internal audits is planned and implemented. Checks should be made and recorded against all procedures at a frequency appropriate to the importance of the subject. In case non-conformances are identified, corrective actions should be scheduled with designated responsibilities and timescales.

10.4. MANAGEMENT REVIEW

The quality management system should be subject to review, at least once per year, in order to assess that it is providing the level of food safety and quality required. The review meeting should be chaired by senior management and topics discussed could include; the results of internal and external audits, customer performance indicators such as complaints, incidents within the factory requiring corrective actions, review of the HACCP system, technical or legal developments of relevance to the operations of the company, and resource requirements. KPIs (Key Performance Indicators) should be established, and progress in meeting such objectives monitored, during scheduled management meetings throughout the year.

10.5. TRACEABILITY AND RECALL PROCEDURE

Canned fish products have long shelf lives and it is consequently important that there is a traceability system capable of precisely identifying a product, in which a problem may have been identified at some time after manufacture. The traceability system must be capable of servicing a product recall if this is considered necessary. The recall procedure itself should be fully documented, defining the responsibilities and actions of senior personnel in case of recall.

10.6. CERTIFICATION

Companies may elect to seek certification to one of the schemes recognized within the Global Food Safety Initiative such as the British Retail Consortium Global standard for Food Safety or the German/French International Food Standard. Indeed, in practice it may be obligatory if companies wish to sell to the major retail or trading organizations.

11. QUALITY CONTROL LABORATORY

11.1. GENERAL CONSIDERATIONS

The function of the quality control laboratory is to undertake testing that provides evidence of conformance (or otherwise) with product and process specifications. This may include physical, chemical, microbiological and sensory testing. It is likely that the scope of testing undertaken is relatively limited, and more specialized analyses may be contracted to external accredited laboratories. It may also be the case that the local competent authority requires parallel analyses to be conducted (typically for histamine content), prior to release of product for export.

Within the factory, it is important that the operations of the laboratory offer no risk of contamination to the food materials within the factory. The laboratory should be positioned apart from the manufacturing areas, extraction vents to the outside should be provided as necessary, and drainage should not be allowed to flow back into process areas.

Areas of the laboratory are required for different functions. It is necessary that sensory testing is carried out in a separate location apart from chemical and microbiological testing.

Testing schedules should be defined and in some cases may be stipulated by customer organizations. Persons carrying out the testing should be suitably trained against the analytical procedures they are required to carry out. Such training should be recorded. Recognized methods of analysis should be used, such as those published by the International Organization for Standardization (ISO), or in the official AOAC methods of analysis textbook.

11.2. SCOPE OF LABORATORY OPERATIONS

The scope of testing carried out within the quality control laboratory is likely to include:

- Physical examination of raw material fish for freshness;
- Determination of ABVT (TVBN) as an indicator of freshness;
- Determination of histamine in raw fish and finished products;
- Determination of concentration of salt content in brine or finished products;
- Determination of brix of tomato paste;
- Determination of peroxide value of vegetable oil;
- Determination of free residual chlorine in can cooling water;
- Microbiological testing of food contact surfaces for validation of cleaning methods by use of swabs or ATP kits;
- Incubation testing of finished products at 37 °C for ten days and 55 °C for seven days to include measurement of any pH change;
- Shelf life testing of products on a scheduled basis;
- Sensory testing of finished products. Taste panels should include a selection of personnel from various functions within the company and not be limited to laboratory staff;

- Analysis of double seams. Such testing should be carried out in a suitable location to ensure there is no risk of metal fragment contamination;
- Measurement of temperatures of storage rooms and process areas having controlled temperatures;
- Heat penetration testing to validate the thermal processes used in sterilization; and
- Temperature distribution testing to validate the uniformity of temperatures with retorts during thermal processing.

External laboratories used for more complex testing should be accredited against the ISO 17025 standard (ISO, 2005b). Such testing may typically include:

- Determination of heavy metals in fish;
- Determination of pesticides in fish;
- Microbiological analysis including the presence of pathogens in the case of spoiled cans;
- Microbiological analysis of water used in product make up or for can cooling;
- Nutritional analysis;
- Compositional analysis of vegetable oils; and
- External laboratories may also be used for competency testing of the company's own laboratory personnel.

11.3. RECORDS

Results of laboratory testing must be retained, at least, for the expected shelf life of the company's products. Certain customers may in practice request longer periods of retention. It is important that records are readily accessible, and if retained on a computer system, that a suitable backup system is employed in case of computer failure. It is normal for all the test results from one day, including can seams tested, to be kept together in a day file. Record forms should be individually identifiable by serial number, and should be included in the system of controlled documentation.

11.4. HISTAMINE TESTING

Histamine testing is one of the most important analyses conducted in the laboratories of companies processing scombroid species of fish, principally sardines, mackerels and tuna. The legal limit for histamine in canned fish is defined in EC 2073/2005 (EC, 2005a) as 100 mg/kg, with no more than two samples in nine having up to 200 mg/kg. In commercial practice however, customers are more likely to specify a maximum figure of 50 mg/kg. The method for analysis of histamine may be specified by the local competent authority. There are three possibilities, a rapid technique using commercially available ELISA kits, the traditional spectrofluorimetry method, and the most accurate, but possibly most expensive method, using HPLC equipment.

12. PERSONNEL AND SERVICES

12.1. PERSONNEL REQUIREMENTS

The number of personnel to be employed in a fish canning factory will depend on the manufacturing capacity, the complexity of the range of products made, and the extent of mechanization of the processes used. The extent of mechanization may itself depend on the local availability and cost of manual labour. Typically, a sardine factory processing some 65 tonnes per day of fish during one extended day shift, with manual preparation, will employ approximately 400 workers. Similarly a large tuna cannery processing 350 tonnes during 3 shifts in a 24 hour operation, might employ 2400 workers. On the other hand a highly mechanized mackerel factory processing 60 tonnes per day might use 130 workers.

If local labour is not available, there is the option for contracting imported personnel. There will be a cost involved in the provision of necessary accommodation and social facilities.

12.1.1. Personnel training

It is necessary that all personnel receive adequate induction training on joining a company that explains the company's food safety and quality policies, hygiene regulations, health and safety considerations, and terms and conditions of employment.

Further training should be provided against specific working procedures, so that all personnel are judged to be competent in the tasks they are required to complete. Records of training should be maintained and provide details of the trainee, the trainer, the date of training and the topic.

12.1.2. Personnel hygiene regulations

The company should specify the hygiene regulations to be adopted in the cannery, and these should be fully explained to all workers. Typically, they should include:

- Requirements for hand washing, on entering the factory, after using toilet accommodation, and as necessary during manufacturing operations.;
- The correct use of protective clothing, and including instructions on home laundering if centralized laundering is not available;
- The issue and use of metal detectable plasters in case of small cuts or grazes;
- The jewellery policy. It would be normal to restrict the wearing of jewellery to a plain wedding ring. Watches should not be worn; and
- Restrictions on eating or smoking within the factory apart from within dedicated facilities provided for the purpose.

12.1.3. Personnel medical screening

It may be a statutory requirement, depending on the country of manufacture, that all employees are subject to a medical examination in order to assess their fitness for work in a food factory. If not, it is nevertheless a sensible measure that prospective employees are screened, at least by completion of a medical questionnaire. In case of doubt, reference should be made to a suitable medical authority such as an occupational health department.

12.1.4. Protective clothing

Protective clothing should be provided for all personnel appropriate for their appointed tasks. The protective clothing should be designed so that it does not provide risk of contamination of the materials being processed. It should cover personal clothing and should not have external pockets above the waist or sewn on buttons. Head covering should be designed and provided to prevent any possibility of contamination of product by hair.

12.2. SERVICE REQUIREMENTS

12.2.1. Steam

Steam is the primary heat transfer medium used for the heating of pre-cookers and retorts. The steam requirement and consequent boiler capacity will depend on the number and type of retorts deployed, and the manner in which retort cycles are scheduled. The steam demand is proportional to the difference in temperature between the inside of the retort and the scheduled process temperature. Hence, the steam demand is greatest during the come-up phase and decreases as the retort approaches its scheduled temperature. The demand will be proportionally higher if the manufacturing schedule allows two or more retorts to be brought up to temperature at the same time. In general, the optimum come-up time should be in the order of 8–12 minutes and the boiler(s) should be sized accordingly.

Simple saturated steam retorts operate at the significantly lower pressure of about one bar, in contrast to overpressure retorts that require a steam supply in the region of 6 bar. All retorts will have been tested to a safe working pressure, and it is obligatory that appropriate reducing valves are fitted between the boiler steam supply and the retort, so that the SWP may not be exceeded.

Further details on the steam requirements for retorts are provided in section 8.5 of the Fish Canning Handbook, ISBN 978-1-4051-8099, 2010. There should be an indication of steam pressure in the retort area for the information of the retort operator and an alarm fitted in case of steam failure.

Steam, if in direct contact with food material as in the case of pre-cooking, should be of culinary quality. Boiler feed water treatment chemicals in consequence must be suitable for the intended purpose. Final steam filters should be used, which are capable of removing all particles larger than five microns.

12.2.2. Water

Water is an essential utility in canneries for use in product preparation, retort cooling, steam raising and cleaning. The source of water may be from the municipal supply, private wells or both. The water treatment subsequently required will depend on the intended use.

All water used in product preparation should be of potable quality as defined in EU Drinking Water Directive 98/83/EC (EC, 1998). Mains water should meet this standard at the point of reception at the factory and responsibility for compliance is that of the municipal authority. Water samples should subsequently be taken from various sampling points within the distribution system and subjected to microbiological analysis for coliforms and total aerobic counts at 22 °C. Normally the total count should be less than 100 organisms per milliliter after incubation for three days at 22 °C, and coliforms should not be detectable in 100 ml of 95 percent of samples taken, nor in any two consecutive samples of that series. Total counts should be taken weekly and coliform counts at least once per month. Well water may require filtration through sand and/or carbon filters prior to use.

If water is to be used for can cooling in retorts, the treatment required will depend on whether cooling is by direct contact or indirect contact as is the case with those retorts fitted with external heat exchangers. If direct cooling is used, the water must be sanitized. The most frequently used form of sanitation is by the addition of chlorine, either as chlorine gas or as sodium hypochlorite. The requirement is that free residual chlorine is present in the cooling water on exit from the retort. A figure of 1 ppm would be considered normal. As an alternative to the addition of chlorine, cooling water may be sanitized by ultra violet radiation, the slight drawback being that there is no residual sanitizing effect in the water once treatment has been completed.

Ultra violet systems are also used for the sterilization of water. However, there is no remaining sanitizing effect within the water and if the pipework to the point of application is excessive, there may always be the possibility of recontamination.

If indirect cooling of cans is used there is no need for sanitizing of the water. If the cannery is adjacent to the sea, there is also the possibility that seawater may be used for can cooling purposes. In such case however, it is necessary that the heat exchanger is constructed of titanium in order to avoid corrosion of the metal from hot, salted water. Water is an expensive commodity and it would be normal to consider the recycling of water through cooling towers prior to re-use. The effectiveness of cooling will depend on temperature and flow rate. The manufacturers of the retort should provide guidance on the water requirement of their equipment.

As guidance, the total volume of water required for all operations is estimated for a cannery processing 20 tonnes of raw tuna in 8 hours as 80 m^3/hr and for a sardine factory processing 15 tonnes of fish in 8 hours as 70 m^3/hr.

12.2.3. Compressed air

Compressed air is required for operation of control valves and for providing pressure to the retorts. Air pressure is required during cooling of saturated steam retorts to prevent cans peaking, and as overpressure in water retorts to maintain the water in the liquid phase. Flow rate of air is important and a buffer tank should be positioned between the air compressor and the point of application in order to cope with fluctuations in supply and demand. The compressor in the case of water retorts should be capable of generating 6 bars pressure within the air distribution system.

12.2.4. Maintenance

Machinery within the cannery is complex in nature and should be subject to routine scheduled maintenance. The frequency of inspection and servicing should be based on the recommendations of the manufacturer, and on historical knowledge gained in the use of the particular item of equipment.

Maintenance should be recorded and a history maintained of problems encountered with the main engineering assets. Technicians should be suitably trained in particular those responsible for the servicing of double seaming machines. Specific training courses may be available from the manufacturers of the machines or the can suppliers.

Engineering activities should not give rise to risk of contamination of product by engineering components, or items of plant. At the completion of engineering work, a hand-back procedure should ensure that machinery is clear of all tools and other items and has been suitably cleaned for re-use in manufacture. Engineering workshops should ideally be situated away from immediate production areas, clean and tidy, and organized to prevent any contamination risks to product.

12.2.5. Calibration

Instruments, which are used in the control or monitoring of processes critical to food safety or quality, should be calibrated according to a defined schedule by a suitably qualified organization. The schedule should include, the instrument, type, serial number, where deployed, range, resolution required, calibration frequency, date of next calibration, and the calibration agency.

13. SUPPLIERS OF EQUIPMENT

Angelus Sanitary Can Machine Company - Double seaming machines
4900 Pacific Boulevard,
Los Angeles, California (CA), 90058
USA
www.angelusmachine.com

Arenco VMK - Fish preparation equipment
P.O. Box 91
SE-391 29 Kalmar
Sweden
info@arenco.com

Baader - Fish cutting and preparation machinery
Nordischer Maschinenbau, Rud Baader GmbH+Co.KG
Geniner Strasse 249
23560 Lübeck
Germany
www.baader.com

Cabinplant - Complete fish processing lines, Herring Mackerel, Tuna
Cabinplant A/S, Roesbjergvej 9
DK-5683 Haarby
Denmark
cpi@cabinplant.com

CFT Packaging S.P.A. - SIMA double seaming machines
Via Paradigna 94/A
43100 Parma
Italy
info@cftpackaging.euin

dft-technology GmbH - Retorts and can handling systems
Rendsburger Str.93
D-24537 Neumünster
Germany
mail@dft-technology.de

Ellab A/S - Heat penetration test equipment
Trollesmindeallee 25
DK 3400, Hilleroed
Denmark
info@ellab.com

Ferrum - Double seaming machines
Bahnstrasse 18
CH-5102, Rupperswil
Switzerland
www.ferrum.ch

Hema - Fillers, irregular vacuum or atmospheric seaming machines
5 Rue Hervé Marchand
29556 Quimper, Cedex 9
France
www.hema-filler.com

Hermasa - Tuna fillers, Complete process lines
Parque Tecnológico y Logístico de Vigo
Parcela 10.01 Calle C-4, 36314 – Valladares, Vigo
Spain
comercial@hermasa.com

Lagarde - Retorts and can handling equipment
Z.I. Les Plaines-No. 5 bis
26780 Malataverne
France
lagarde@lagarde-autoclaves.com

Lubeca - Retorts, can handling equipment, complete lines
Lubeca Maschinenbau Scholz GmbH & Co.KG
Untermehmensbereich Lubeca, Rottkamp11
48653 Coesfeld
Germany
www.lubeca.de

Luthi Machinery Company Inc. - Tuna fillers, purchase or lease
1 Magnuson Avenue
Pueblo, CO 81003
USA
www.luthi.com

Prominox SA -
Km 12, Boulevard Ahl Loghlam
Sidi Bernoussi, Casablanca
Morocco
www.prominox.com

Shin I Machinery Works Co. Ltd. - Filling and double seaming machines, can making
43 Chung-Cheng Street
Ching Shui, Taichung
Taiwan
www.shinican.com

Sommetrade - Double seaming machines, including those for irregular cans
Parque Tecnológico de Zamudio, Edificio 301
48170 Zamudio, Vizcaya
Spain
commercial@sommetrade.com

Steriflow Barriquand SAS - Retorts and general metal fabrication
32 Rue De Cambrai
75019 Paris
France
www.steriflow.com

Surdry - Retorts
Poligono Industrial de Trañapadura
48220 Abadiano, Vizcaya
Spain
surdry@surdry.com

Tacore S.L. - Turnkey canning lines
Rubianes Apartado 245, Villagarcia de Arosa
Pontevedra 36600
Spain
www.tacore.es

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Codex Standard for Canned Shrimps or Prawns, *CODEXSTAN 37-1981*

Codex Standard for Olive Oils and Olive Pomace Oils, *CODEXSTAN 33-1981*

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Campden Food Quality Specifications Standard Canned salmon, Specification L50 Campden BRI

Campden Food Quality Specifications Standard Sardines in oil, brine or water Specification L53 Campden BRI

Campden Food Quality Specifications, Standard Sardines in tomato sauce, Specification L54 Campden BRI

Campden Food Quality Specifications, Standard Tuna chunks in oil, brine or water, Specification L74 Campden BRI

Campden Food Quality Specifications, Standard Tuna flakes in oil or brine, Specification L52 Campden BRI

Campden Food Quality Specifications Standard Tuna steaks in oil, brine or water, Specification L75 Campden BRI

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