Volume I

A COMPLETE COURSE IN CANNING

TENTH EDITION – 1975

A technical reference book and textbook for students of food technology, food plant managers, product research and development specialists, food brokers, technical salesmen, food equipment manufacturers and salesmen, and food industry suppliers.

Revised and Enlarged by

ANTHONY LOPEZ, PH.D.
Professor of Food Science and Technology
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia

A PUBLICATION OF

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BALTIMORE, MARYLAND

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PREFACE

In the last few years many changes have taken place and a great deal of progress has been made in the field of canning. This applies to both technology and to changes in laws and regulations. These developments have made it necessary to completely revise, update, and expand the ninth edition of this book. New sections on food laws and regulations, ingredients, microbiology of canned foods, and energy conservation have been added. Other material in the past edition has been expanded, such as that concerned with plant building and equipment requirements, containers, cannery unit operations, and warehousing of canned foods. The glossary of terms has been considerably enlarged to include many technical terms that lately have come into common usage in the canning industry. These terms are found in regulatory literature, quality control procedures, waste disposal methods, container specifications, and in basic canning technology publications.

All of the above could not have been done without the cooperation of many individuals and firms, and of several federal agencies. The author is grateful for their help and acknowledgements have been made. National Canners Association deserves special recognition because material from several of its excellent publications was incorporated in the book.

It is hoped that this tenth edition of "A Complete Course in Canning" will be most useful to canners and to other persons associated with the canning industry.

Anthony Lopez

Blacksburg, Virginia

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CHAPTER 1

BASIC INFORMATION ON CANNING

THE CANNING INDUSTRY

The extent of the canning industry in this country has increased beyond the wildest dreams of the most ardent early enthusiasts. The industry now produces some 1400 different canned food items including fruits, vegetables, juices, fish and seafoods, meats, soups, baby foods, milk, and specialty items, with a total annual production amounting to more than 34.5 billion pounds, or about 37.3 billion containers. The canning industry comprises about 1500 canneries in 49 states. Production line workers in the canning industry receive wages and salaries totaling more than $750 million annually. At peak season employment in the industry totals more than 340,000. Canners pay farmers and other producers about $1.5 billion annually for the raw products. The retail value of canned foods packed annually amounts to about $9.4 billion.

The general standard of living is better and in no particular is this more pronounced than in the selection and use of foods. Better food, better clothes, better homes, and better working conditions are correlated. Better foods mean better health, which begets the desire and ability to attain the other ends. As long as the canner furnishes better foods than the majority of persons have been accustomed to using, there will be an increase in their consumption. Whenever better food, not cheaper food, can be secured in another form, whether it be dehydrated, frozen, or what-not, then the field of the canner will be curtailed. It, therefore, behooves the canner to constantly strive for increase in the higher grades, and to study new combinations and methods of packing. The industry cannot be built up or expanded on "seconds," "water," or "pie" grades.

The canning industry must recognize that there are powerful competing factors. Thousands of carloads of fresh vegetables–peas, beans, spinach, cabbage, carrots, tomatoes, etc., are produced in the South and in Mexico and shipped to markets in the North during the winter and spring. The ease of preparation and other conveniences of canned foods give these products important advantages over fresh foods.

Government food experts, educators, and domestic science teachers teach the benefits of varied diet, the value of fruit and vegetables, etc., as health-building and conserving, so that these are used to a greater extent in the homes of lower and middle income families than they formerly were used by those in the highest income bracket. The economy, convenience, and good nutrituve value of canned foods helped in the development of that trend and is sharing in the increased consumption of fruits and vegetables, and of convenience foods in general. Canned foods generally compare favorably from the nutritive standpoint with the same fresh foods cooked at home. The annual per capita consumption of canned foods in the U.S. in 1972 was 150 pounds, or slightly more than 10% of the 1,452 pounds figure for per capita consumption of all foods.

LOCATION OF PLANT

There are many factors which determine the suitability of any location for a cannery. The more important are: availability of an ample supply of raw products of the desired quality at prices which are satisfactory to the growers; an adequate supply of water of suitable quality; the availability of adequate help during the canning season; availability of regular transportation at reasonable rates between the cannery and the primary markets, and adequate facilities that comply with local, State, and Federal laws for the disposal of plant waste.

The economies of production will determine in a very large measure the location of a factory with reference to these important items: raw materials, water supply, labor and shipping facilities. The order of the importance of these factors will not be the same in each line of canning, but will be dependent upon the amount of labor required, the nature of the raw materials as to perishability, and the amount of waste. In the case of fruits requiring much hand labor, or a factory operating over a considerable part of the year, it will be found more economical and satisfactory to haul the product by rail or truck rather than to transport the help. In the case of corn, where the waste in husk and cob is such a large part, and where machinery has displaced workers, the reverse may be true. Peas formerly belonged in the same class as corn, but since the vining is being done in the field or at viner stations in the country, and only the shelled peas are trucked, the factory may be located at any good site. Choosing a location with reference to labor should go further than merely getting near, or in, a city or large town, but should be in a vicinity that will attract the better class of women and men willing to work. As a rule the smaller towns are preferable to cities. Growers dislike long hauls with raw products through congested streets as this greatly increases the cost of crop delivery. The importance of good help should, therefore, be given the closest consideration. The physical equipment may be purchased or built, but labor can be made efficient and satisfactory only through training of intelligent help having good, proper standards of living. Moreover, efficiency cannot be developed with different personnel each year. Waste disposal is usually more expensive in cities or large towns than in more open areas.

There is no question as to the advantage of locating a factory near the fresh material. It is a necessity for the proper handling in the case of some products, such as asparagus and corn, and is desirable in all cases, as it permits leaving the product to mature to its best stage and lessens injury from handling and deterioration from changes after harvesting.

For fruit and vegetable canneries and other industries that are dependent on farm products, it is important to consider the suitability of the region, particularly with respect to soil, temperatures, rainfall, etc., for growing the varieties of raw materials adapted for canning. Canning has developed beyond the point where a plant can be successfully operated without the specialized farming of suitable varieties. A cannery cannot be successful if it depends upon the use of either culls or occasional surpluses as sources of its raw materials.

The varieties of vegetables used for canning are selected because of their suitability. Canners generally furnish the seed and supervise crop growing, furnish instructions on special methods of production and control of disease and insect pests and harvesting and delivery times and methods.

Usually the state colleges of agriculture can be of assistance in assembling the necessary information with respect to the suitability of a region for producing canners' crops.

The site should be one easily accessible for the receipt and shipment of raw and finished materials and for help. It should have ample space and be in a clean locality. There must be opportunity for the disposal of waste, whether it be carried by the wash water or be bulky and need to be removed by truck. Air and light should be accessible to all sides, and the yards hard, with ample slope for drainage. A food factory should be the cleanest place in the community.

It does not follow that the same kind of a location is necessary for all factories. Many meat canning establishments are near a slaughter house, and usually the yards, with their attendant distinctive odors, cause conditions which should be sufficient to condemn the place as suitable for the packing of fruits and vegetables. The same deduction might be made for a fish factory, and yet both be thoroughly clean and suited to their particular lines of packing. Most seafood canneries are in isolated locations but some operate near centers of population. A waterfront location near a residential area is not desirable even though it may not be forbidden by zoning regulations. No matter how careful the management might be to keep the establishment clean and to eliminate any possible nuisances, the presence of the plant will be resented, the operations will encounter hostility and the product will receive unfavorable advertising.

The market potential in the area where a plant is to be located should also be considered. The population trends in the area should be checked and estimates made of the expected trends in the next five to ten years. Per capita income should also be checked and the trends of this item noted for the area. These factors will have an important bearing on the possible market outlet in the immediate vicinity of the plant location. In general it is desirable to sell as high a proportion of plant output as possible within a 100 or 200 mile radius of the plant location to minimize transportation and other costs.

FACTORS INFLUENCING PLANT LOCATION

Purpose

It is the purpose of this section to call attention to those factors which should be considered in the location of a new plant. The basic objective is to choose the one location which results in the best possible combination of individual factors affecting the total production cost, thus assuring maximum profits from a company's operations.

It would seem that enlightened self-interest would demand a complete factual study of a plant location factors by a company's staff or by outside qualified consultants. Unfortunately, in practice, there are many instances where no thorough analysis is made and where plant location is determined on the basis of a few rapidly gleaned impressions during a hurried site tour, or by likes and prejudices which normally should not play a part in the solution of the problem.

Procedure

Following is a compilation of basic questions which management must answer and evaluate in order to select the best possible site for a new plant.

From this list should be selected all questions that refer to specific factors which contribute to the total cost of products and services of the plant being considered. The factors to which questions refer are not of equal importance; their relative importance will vary from plant to plant. Sometimes, the scale of importance can be established by evaluating the percentage of the total cost of a plant's products which each factor bears. This percentage can then be used as the "weighted value" for each factor.

If this would be impractical, it is sometimes expedient to prepare a simple listing, in order of their importance, of factors which affect the total cost of products and services of the plant being considered. If 30 items are involved, the most important is given a weighted value of 30, the next important a value of 29, etc., until the least important receives a value of 1. These figures can then be used as the "weighted values".

In some cases, it may be necessary to assign a "weighted value" on an arbitrary basis of considered and experienced judgement where it is agreed that a special factor warrants unusual value. For instance, there have been cases where plant management has been restricted in its choice of a plant site due to the inability of obtaining competent supervisory personnel in areas at some distances from the home plant.

When the final list of factors has been established and weighted values agreed upon, the selection of general areas favorable to the new plant can proceed. Generally, there are two or three factors which automatically limit the areas where a plant can be built. For example, canning plants require large supplies of water and good facilities for effluent disposal. Such locations in the United States are limited in number and only areas where such facilities are available are worthy of detailed investigation. In other plants, a large supply of power at low cost is of primary importance. Similarly, this becomes a controlling factor and limits the locations to certain sections.

Another method of defining general areas for plant location is by a study of raw material souces and market destinations. The object of the study is to develop factual data on incoming and outgoing freight to determine the areas which combine maximum economies for receipt of raw material and for distribution of manufactured product. Any area defined by this method should be carefully scrutinized to insure that other important factors do not suffer to a degree which would overbalance the freight consideration.

Search for a Specific Location

The next step is the detailed search for a specific location within general areas already isolated. Chambers of Commerce, real estate firms, industrial engineers and builders and railroads in these general areas can be sought out and advised in detail of characteristics needed for the ideal site. Many of these agencies will be familiar with tracts of land which may fulfill requirements for the new plant. They are also able to provide much data which will be needed to answer questions posed in the "Factors Influencing Industrial Plant Locations."

After a list of potentially suitable sites has been developed, field crews can be assigned to visit and inspect each of them. The objective of inspections should be to rate or grade each site as to the degree with which it meets requirements of factors which have been assigned "weighted values." The grading should be done numerically, i.e., "5" for excellent, "4" for good, "3" for fair, "2" for poor, and "1" for impossible.

The "weighted value" for each factor is then multiplied by the "grade." The product represents a numerical value of the factor which combines its importance to the production process and its degree of excellence as related to a specific site. The sums of these products for the various sites can be used as a fair and reasonably accurate basis for the comparison of one site with another.

Value to Management

The great value to management of a careful and scientific plant location study may not always be appreciated. If properly developed and interpreted, such a study will insure that the location selected will basically establish the lowest possible level of production cost.

This in turn helps to establish the plant's competitive strength in relation to other competing plants seeking to command the same markets. Competitive strength contributes to steady growth and thus to an increasing share of the profits available in the industry.

Location studies can easily be made by the company's own engineering staff if it is properly equipped to do so. Otherwise competent outside engineering talent should be engaged to insure that proper attention is given to so important a problem.

BASIC CONSIDERATIONS IN EVALUATING PLANT LOCATION

(a) Production Materials

1. What are delivered prices of raw and partially manufactured materials at the site?
2. Are these costs competitively favorable to you?
3. Are materials available in sufficient quantities?
4. What is their comparative quality?
5. Are the sources of materials dependable over a long period of time?
6. Are emergency sources available?

(b) Marketing

7. What is the cost of delivering finished goods to markets and customers?
8. Are these costs competitively in your favor?
9. Can the products be serviced quickly and easily?
10. What percentage of the total market can be serviced directly from the plant?
11. Can sales, sales promotion and advertising be effectively conducted?

(c) Transporation and Distribution

12. What transportation facilities are available, including railroads, highways, waterways, pipelines, airways, postal service, etc.?

13. How dependable are the transportation facilities? Are there seasonal fluctuations in availability?

14. What is the quality of service and the ability to handle such tonnages as are likely to be required in the foreseeable future?

15. What are the freight rates, switching rates, speed of movements, headway between departures, correlation of freight schedules with production and switching schedules?

16. Are adequate storage, warehousing and terminal facilities available together with financing services, grading and inspection of goods, etc.?

(d) Labor

17. Is an adequate labor supply in the vicinity already available or potential through movement of workers within range of the site?

18. What percentage of the labor supply is male? Female?

19. What is the available range of skills in the labor market?

20. Are highly specialized skills required by your production available in sufficient quantity?

21. What is the relative efficiency of labor as established by the experience of others?

22. How stable is local labor as indicated by turnover rates of other manufacturers?

23. What is the percentage of homeowners in the labor group?

24. How restrictive are shop rules governing workers in other plants?

25. What is the state of labor relations as indicated by local experiences of other employers in strikes, mass picketing, civil disturbance, etc.?

26. What is the local unemployment experience?

27. Does any local industry dominate the entire local labor market?

28. How large is the area from which employees can be drawn and what is the employable population of this area?

29. What are local rates of pay for jobs comparable to those required in the new plant?

30. Do these rates represent any competitive advantage?

31. How stable are these rates?

(e) Supervision

32. Does the new location facilitate general management supervision from executive headquarters?

33. Can adequate supervisory personnel be drawn from the area selected or induced to locate there?

(f) Utilities, Service and Fuels

34. What sources and quantities of water are available?

35. What is the cost of water?

36. What reserves of water are available and how large are they?

37. What is the chemical content and other characteristics of the water as relates to its suitability for process or steam?

38. How can the problem of induatrial waste be handled?

39. Are local facilities available for sewage disposal?
40. What is the local cost of power-present and future?
41. Is it available in adequate quantity?
42. How dependable are sources of power supply?
43. What is the cost locally of gas, oil and coal?
44. Are these commodities available in adequate quantity?

(g) Bank Facilities

45. What are the number and size of banks in the locality under consideration?
46. What is the amount and supply of loanable capital?
47. What is the maximum loan any one bank can make to one customer?
48. Are banking facilities adequate for handling the payroll?
49. What are the banks' correspondents and financial connections?
50. What is the bank's attitude towards industry?

(h) Laws and Taxes

51. What are existing laws and practices with regard to
    a. Workmen's Compensation
    b. Unemployment Compensation
    c. State and Local Building Codes
    d. Safety and Insurance Regulations
    e. Stream pollution and waste disposal
52. What is the public attitude towards industry as indicated by existing laws and regulations?
53. How well are existing laws administrated and is this administration alert and progressive?
54. What are local taxes for:
    a. Real property
    b. Classified property such as machinery, inventories of raw materials and finished goods
    c. Deposits and investments
    d. Corporate and personal income
    e. Sales and Use Taxes
    f. Organization or franchise tax
55. Will an adjacent city annex the plant site and thus eliminate tax advantages?

(i) Community Attitude Towards Industry

56. How sincere a welcome would be extended to your business by the community under consideration?
57. Will the community attract your type of industry by offering tax or other inducements?
58. Does the community show an interest by offering assistance in matters such as site location and selection, extension of utility lines, modification of obsolete restrictions and the like?

(j) Living Conditions

59. How do living costs in the locality compare with other sections of the country?

60. Are housing facilities available for workers coming from other sections of the country? Or, if not, does the community have adequate plans for relieving the housing shortage?

61. Are community facilities including schools, churches, hospitals, and recreational facilities adequate?

(k) Climate

62. What are the range and mean weather conditions, including snowfall, rainfall, storms, humidity, etc.?

63. How do local weather conditions affect plant costs, labor, production, transportation and living conditions?

(l) National Defense

64. Does the location meet requirements established for general security standards to be considered in the industrial dispersal program?

SITE CHARACTERISTICS

Factors to be considered in the selection of a specific site within a desirable plant location.

(1) Are existing plants or buildings available in the proposed location? Could these be converted at a reasonable cost to meet new plant requirements and maintain optimum efficiency?

(2) If new facilities are to be built, is there sufficient acreage available to permit an attractive setting for the plant, future expanstion and adequate parking facilities?

(3) Is the contour of the site such that a minimum of grading or other treatment will be required?

(4) Is the site elevation sufficient to avoid any possibility of flooding?

(5) What are the subsoil characteristics? Will expensive foundation, piling or drainage costs be encountered?

(6) Is the land cost in line with the inherent advantages of the specific site?

(7) Can the site be purchased outright or only leased?

(8) What is the cost of connecting utilities and access roads to the plant?

BUILDING A CANNING PLANT

CONSTRUCTION FACTORS

In building a modern cannery, many factors will play an important role in its operation, and will be seriously felt if by chance they are overlooked. These might be listed as follows, and their order of importance would be somewhat changed according to the size of the operation:

1. Adequate water supply to meet current needs as well as future needs.

2. Adequate sewage outlet to carry off water used in washing product, as well as cooling finished products, not only for current needs, but also for future increased output. Few canners realize how many gallons of water they use daily, and what would happen to them if sewers were too small to care for waste water if output should be considerably augmented. It does not require much of an opera-

tion to use 500,000 gallons to 1 million gallons of water daily. In calculating in this respect, due allowance must be made for increased load upon the sewer caused by expansion of other industries in the adjacent area, or an increase in homes using the same sewage outlet. Independent sewage treatment facilities may have to be considered.

3. Adequate land of sufficient load-resisting capacity for immediate needs and expansion, as well as for storage and parking facilities for employees.

4. Adequate strength in the building to withstand overloading (for instance heavy snow on roofs in the Pacific Northwest), adequate drainage outlets to take care of sudden excesses of rainfall, and adequate reinforcing to meet demands of heavy loads resulting from high stacking of finished goods and the shock of movement of heavily loaded lift-trucks across floors.

5. Ample height to permit free use of conveying systems, or double-decking of machinery and equipment if necessary.

6. Adequate ventilation to prevent condensation of steam from raining onto products, as well as to insure worker comfort.

7. Heating facilities (where needed) to insure comfortable working space for employees and to prevent freezing of finished product stored in cannery warehouses.

8. Adequate room for oversize sidings to prevent costly standby time of workers waiting for switch engines to bring more cars.

9. Buildings should be streamlined with as few posts as possible. Partitions should be built so they can easily be removed to prevent the building from becoming a "special purpose" building, in event canning operations should be suspended. This would facilitate getting a construction loan or selling later if necessary. All inside concrete walls should be brushed with waterproof cement to fill all crevices and holes to prevent accumulation of dust or mildew spores.

A plant built in an east to west direction, or vice versa, is much better for lighting.

Local city, state and federal construction codes should be examined to insure compliance with all regulations relating to fire, worker safety, etc.

Many of the preceding factors will require different treatment according to local conditions in the area where the plant is built. For example, the problem of snow load on roofs is not material in California. In the Northwest, engineers allow for a possible load of 30 lbs. of snow per sq. ft. of roof, and drainage pipe for water from roofs is calculated to provide an outflow resulting from a flash flood of 1" of rain in 30 minutes.

Earth resistance is very important. High stacking of canned foods with lift trucks has increased static loads greatly per sq. ft. Where soil is soft, it often is necessary to drive more or less piling to prevent yielding and shifting of floors. Wherever floors are laid over sewers or places where trees have been removed, floors should be more heavily reinforced to prevent cracking because of low soil resistance.

Reinforcing of floors is requiring more attention than in the past. It can readily be seen that a lift-truck, moving a 3-ton load on 4 points of contact-where wheels touch the floor-which in the aggregate are not over a total of 1 sq. ft. in area, places a tremendous strain on floors. Moving loads create greater strain than static loads of the same weight per sq. ft.

Earthquake proofing is generally overlooked, but since it will add only about 1% to the cost of building, it is almost gross negligence to omit this precautionary measure. Earthquake proofing a cannery consists mainly in tying the building together in such a way that when it is shaken, the whole building will move together as one unit. It is assumed, of course, that if the building is of concrete, the walls, as well as floors, are steel-reinforced.

Columns–It is not considered good practice to place column footings on top of floors as this tends to contribute to cracking of cement. They should be placed beneath floor levels. When concrete for floors is poured, a pressure strip should be placed around each column to isolate it from the main floor slab. This permits the floor to rise or recede without breaking cement around the column.

To protect columns from lift-truck damage, the bottom of the column is encased with a steel pipe, which is to be filled with cement. Above the pipe, cement should be rounded upwards to eliminate a shelf where dirt and rubbish can accumulate. If these pipe-guards can be put around columns before the floor is laid, they can extend through the floor to the footing, which is a better way of handling this problem. Where columns protrude through the floor in processing or preparation areas and have no cylinders around them, cement should be coved upwards within their flanges to cause washing water to run away from them instead of pocketing against them and causing rust. Bases of windows also should be beveled to prevent water running under metal sashes and causing rust, as well as to prevent ledges from becoming resting places for cans and other debris. Wherever possible, floors should be so constructed that columns will be at the high point of drainage.

To protect walls of the building against lift-truck damage, especially where there are downspouts or electrical switch boxes, etc., cement curves are built. They should be wide enough to allow plenty of clearance for loads going by. Generally they are about 5 inches high and are beveled backward from the floor at a rate of 1 inch for each 3 inches of rise. The front of the curb is sloped backward instead of being made perpendicular to prevent lift-truck tires from being damaged in case the truck should bump the curb.

Where possible, double walls should be avoided to prevent giving rodents nesting places.

The tendency is to build plants with floors at ground level, and to depress railroad sidings to permit driving lift-trucks directly into cars from cannery floor levels. This partially avoids the cost of heavy gravel fills and ramps and also permits direct entry to the building at both the receiving and shipping areas by either lift-trucks or over-the-road trucks.

Industrial floors, especially those exposed to corrosive spillages, frequently receive less design study than any other part of the building process. The consequences of inattention can be serious. Production may be lost, the stability of structures compromised and hazards to attendant personnel created. An easy and inexpensive method for reducing floor attack is to slope all floors and provide sufficient floor drains. Care must be exercised to avoid uneven areas that will holdup liquids. Monolithic concrete has advantages in certain systems, while floors with scarificial tile may be the most useful solution to spill damage in others. Metal decking with isolated skid-resistant protrusions is much more desirable than interlocking diamond or ring varieties. The latter retain solutions which enhance corrosion of the surfaces.

Floors are being made thicker-mostly 5 and 6 inches in depth-and heavier reinforcing is used. In areas where preparation of raw product is to be done, "dense mix" concrete is being used and often an extra bag of cement is added to each batch. In addition to these precautions, several coats of a silicate type filler is brushed onto the floor, which has the effect of "case-hardening" the surface to a depth of 1/4 inch and of making the surface more impenetrable by fruit and vegetable acids. A floor slope of between one and two percent toward floor drains is recommended to avoid standing water. Machinery should be leveled.

There is some difference of opinion as to whether floors should be made smooth for better sanitation or slightly rough to hold down accidents due to slipping on wet floors.

Current costs for floor drainage systems will prove a shock to any one contemplating construction of a new canning plant. When a floor drain is constructed, it is necessary to build two walls and a bottom, or floor, in the drain. It requires two sets of concrete forms for each wall and one more for the bottom—a total of 5 forms. At current costs for labor and materials, this rapidly runs into money, so the tendency is to place drains farther apart and increase the pitch in the floor to 1/4 inch to the foot instead of 1/8 inch. In that event, part of the handicap of distance is overcome by using drain pipes or troughs to convey water from equipment to floor drains.

Floor Drains are being made with round bottoms to get a better flow when a small amount of water is being moved and also to facilitate cleaning. Fruit and vegetable acids, after a while, penetrate these drain bottoms and create a very unsanitary condition in the concrete below. To offset this difficulty, many types of paint, including one with an asphalt base, have been used to put a protective film over the bottom of the drain. In most recent construction acid-resisting vitrified tile is split in half lengthwise, and these halves are imbedded in the cement in the bottom of the floor drain. These are providing a maximum of cleaniness and require practically no attention for years. It is necessary when laying this tile to "point up" the joints with a special type of acid resisting cement. If floor drains can be made wider and shallower, it permits easier cleaning although it increases the cost of drain covers and tile somewhat.

In order to carry drain covers, it has been customary to lay at the top edge of the drain trough a shelf made of angle iron on which drain covers may lie. It is also customary to cover the edge of the drain at the floor level with angle iron. It has been found desirable to weld these two angle irons together for their full length, not only to prevent seepage of raw product materials between them into the cement of the floor, but also to give them additional strength. These welded angle iron floor edgings and drain cover shelves are anchored securely into the floor with lags penetrating deeply into the cement before it has solidified. Because of heavy stress of shocks from lift trucks crossing these drain covers, it is necessary to provide strong edgings.

Drain covers are generally of sidewalk-type grating. They should be of the type where metal strips stand on edge and are forged together across the top side. This permits pieces of raw product to be washed into floor drains without danger of their being caught in meshes or lying on shoulders of floor drains.

Some canners are putting hose-bibs in the ends of main drains, which can be turned on to give an added flow of water if necessary where waste materials do not carry with them enough water to float them out readily.

When floor drains are laid out, if the canner feels he may want to keep vegetable waste separate from fruit waste, it would be simple to run two master drains out of the building far enough apart so that one could go into a separate compartment at one end of his waste removal screening pit, and the other drain could deliver to another compartment at the other end of the screening pit. In this way, if it became possible to salvage some of the waste for stock feed or for some other purpose, waste originating on one side of the cannery could be isolated from that originating on the opposite side.

PLANNING A CANNING PLANT

In planning a cannery, every effort should be made to locate boiler houses, transformers, pumping stations, etc., as close as possible to the point of use, in order to cut down transfer losses. In purchasing boilers, it is easy to be deceived into buying one with a lower cost per rated horsepower, whereas another boiler with a higher cost per rated horsepower will, because of higher output of steam per horsepower, be cheaper in the end. Canneries generally require a heavy amount of steam for a short period of time. Some boilers of the high-efficiency type can be run at a constant state of overload for a period of 30 days or more and in this way, although they cost slightly more per horsepower, savings can be made by buying less horsepower capacity.

Where a canner is constructing a new cannery, he has an opportunity to do a real job of condensation-damage prevention by running purlins and other lumber used in roofing through a solution of rot preventative. He could also put on an undercoat of paint before this lumber is laid, thereby giving his roof several extra years of life. In putting on the finishing coat of paint on his ceilings, the canner would do well to conduct extensive investigations into the matter of securing a mildewproof paint in which the preventative will not dissolve and drop, through the dripping of condensation, into food that is in a state of preparation. There are many paints for which much is claimed by manufacturers in this respect, but few that will actually pass in the severe test they undergo in canneries.

No set rule can be laid down for sizes of different areas because of wide variation in space required for different types of operations. However, there are some so-called "rule of thumb" bases which can be applied to develop space areas. For instance, there should be receiving room space enough to store at least double the amount of raw product which might be expected for the largest day's run. Ceilings in this area could be high enough to permit over-the-road trucks to back in if necessary without contacting any overhead conveying equipment.

Warehouse storage space should be sufficient, after allowing for aisles, to store 50% of the anticipated capacity of the plant. Obviously, with the possible exception of advertised goods, it is hardly likely that a canner would have 50% of his entire pack on hand at one time. However, loss of space through broken stacks, loss of space needed for labelling equipment, and often space needed for storage of emergency supplies of cans, sugar, labels, etc., use up a considerable amount of his warehouse and must be allowed for. Outlet doors from warehouse space could advantageously be high enough in size to permit over-the-road trucks to back directly into the warehouse for loading. Fire walls between the warehouse and other areas will reduce insurance costs considerably. In some cities they are required by ordinance.

Preparation and processing area must be planned to allow for the length of the longest lines of equipment in both these departments, and there should also be ample aisle space at the beginning and end of these operations, as well as an aisle across, between the preparation and the processing areas. These aisles must be wide enough to permit lift-trucks to maneuver in transporting raw or finished product and also in placing or removing any of the cookers, coolers, preparation tables, or other equipment that may need to be moved from time to time. A great deal of labor cost can be saved if lift-trucks can be used for this purpose.

Loading platforms alongside buildings should be wide enough to permit two lift-trucks to pass and space for a pile of pallets at the loading edge, as well as room for a narrow curb to protect walls of the building, downspouts, etc. Platforms should be a width of 20 feet or slightly more. In the wall of the platform, there should be imbedded, for the full length of the building, a conduit with outlets placed at convenient intervals to permit plugging in lights at any point for night loading of cars.

Ceiling heights should permit free use of all types of conveying systems. The extra cost of 3 to 4 feet more in height of walls and columns is not much compared with savings in costs if it becomes desirable to double-deck some of the equipment. Cannery warehouses usually have 20 feet clearance beneath roof trusses, and many have as much as 24 feet clearance.

There are some other advantages in these heights beside those in the storage department. If cannery walls are high enough, windows can be placed just beneath the roof the full length of the processing and preparation departments. Where sidings are depressed, it is possible, with windows at this height, to run conveyors out to box piles, waste equipment, etc., without conflicting with legal clearance above railroad cars standing on sidings. Where windows are placed lower than roof level, steam tends to pocket in the area over the windows against the roof, causing disintegration of roof lumber. Where windows are at roof level, steam escaping through either monitors or fan-driven ventilators will suck in fresh air, considerable of which will follow the airflow against the ceiling and cut down steam saturation as well as ceiling condensation.

There is some difference of opinion as to the use of monitors in roofs for escaping steam, especially above processing areas, or of fan-operated roof ventilators. It is felt that in the preparation area, power-driven fans could be used for ventilation, but in areas where open-type cookers and exhaust boxes are being used, steam is being released into the air so fast that an adequate power-driven fan system might be used.

There is another advantage in favor of worker comfort in high ceilings. Where ceilings are 20 feet or above, air in the upper 10 feet of elevation will be heavy with warmth and humidity, while the lower layer of about 10 feet will be relatively cool and comfortable.

Waste disposal problems have been complicated and their solution become much more expensive by enforcement of laws relating to stream pollution. Where sewers are small or of low pitch, it is advisable to pump waste to screens located somewhat above ground in order to create a "pressure head" on the sewer to insure adequate outflow of water which has passed through the screens.

Offices of Superintendent, of employment and payroll departments, and quality control office and laboratory should be grouped together. Another group can include warehouse office, label department, mechanical department, and other service-type employees. The first-aid room could be included with either of these but more often is isolated.

Other rooms the canner will want to provide for are: Mechanical superintendent's office, machine shop, parts storage room, electrical equipment repair room, fireproof room for grease and oils, rodent and insectproof room for storage of cans, sugar, labels, pastes, glues, and other supplies. Allowance of space and plans will also have to be worked out for main offices, cafeteria, men's and women's toilets and locker rooms.

If the canner plans to drive a well and furnish most of the water for his operation, he may find it necessary, to comply with fire protection requirements in most cities, to use water from the municipal supply for fire hydrants, toilets, and syrup room, and sometimes it will be found preferable to use city water in his boilers. In that case, water from his own well would be used for washing and cooking. Plants located where city water is not available will make necessary the installation of adequate water treatment facilities to make available water of the quality needed to satisfy food processing requirements.

WATER IN CANNING PLANTS

Requirements and Characteristics

(See Chapter 2, page 275)

CANNERY STEAM REQUIREMENTS

Forms of Steam

There are three forms in which steam may be found, depending on the amount of heat and moisture contained. First is *dry saturated steam*, which is steam formed when water is vaporized and contains no droplets of water or any superheat; i.e., if it was cooled at all, some free moisture would condense out, and if it were heated at all, the temperature would rise, making superheated steam at the same pressure. One pound by weight of saturated steam at atmospheric pressure occupies 26.79 cubic feet, and its latent heat of vaporization is 970.4 BTU.

Wet steam is a mixture of dry saturated steam and water. The water is at the same temperature as the steam with which it is mixed. The water might be in any form but is usually found as drops or films of water. Saturated steam, if cooled slightly, will become wet; for example, if steam is carried for some distance in a pipe, it loses heat, and some of the vapor condenses out to form moisture droplets. This is the kind of steam usually found in food plants.

The quality of wet steam is the weight of the dry saturated steam in this wet steam expressed as a percentage by weight of the wet steam. If the wet steam has a quality of 95 per cent, 95 per cent of every pound of the mixture is composed of dry saturated vapor and 5 per cent by weight is in the form of water droplets. In the above sample in every pound of mixture there would be 0.95 pound of dry saturated vapor and 0.05 pound of water. The total heat of wet steam at a given pressure is less than that of dry saturated steam.

If 1 pound of dry saturated steam is condensed at atmospheric pressure, it will give up 970.4 BTU, but if the steam is only 95 per cent quality, it will give up only $0.95 \times 970.4 = 921.8$ BTU since 5 per cent of the so-called steam is already in the form of water.

Superheated steam is saturated steam which has been heated at constant pressure so *that its temperature is higher than that of saturated steam at the same pressure.* The temperature depends upon the amount of heat which has been added. If superheated steam gives up some heat, its temperature will fall to the temperature of saturated steam at the same pressure before it begins to condense. If additional heat is removed the steam will condense at the same pressure. Superheated steam is obtained by means of special superheating coils in a boiler or by reducing the pressure of high-pressure steam through a throttling valve.

Since the inception of commercial canning, steam has been the principal medium of heat transfer for the preparation and sterilization of canned food products. Other means of heat treatment, like radio frequency, induction and infrared heating for preparation, and cold sterilization by ionizing radiation have been under investigation. Such investigations have generally resulted, however, in methods and procedures which cannot economically compete with steam for the purposes mentioned. There is, therefore, no doubt that steam will continue to be the most acceptable means of heat transfer for many years to come. This competition, however, increases the necessity for emphasis on the efficient production and use of steam in the canning industry. It is important therefore, that an adequate supply of steam suitable to the needs of the various operations be available at the time at which it is required.

Properties of Steam Supply

Steam at pressures consistent with the needs of the various unit operations is necessary if the operations are to be carried out efficiently or even satisfactorily. In general, line pressure of 100 to 125 psi are adequate for most operations if the boiler is properly sized and if the steam lines to the various units are adequate to carry the amount of steam required. Attempts to operate at pressures substantially under these figures usually result in questionable practices or inefficient operation. The retorting operation is particularly vulnerable, as it is almost impossible to accomplish adequate venting at pressures under 70 psi unless exceptionally large and expensive lines are installed.

"Pure" saturated steam, that is, steam free of air or other noncondensable gasses, condensable volatile materials other than steam, excess condensate, and entrained solubles such as boiler compounds and salts, is necessary to preclude the possibility of faulty retort operation, contamination of the products involved and corrosion or other damage to the container. While it is extremely unlikely that any steam supply would carry enough air or other gasses to affect the efficiency of a thermal process, some steam supplies may become sources of product contamination when they carry certain volatiles, excess condensate or soluble materials carried in entrained boiler water.

Soluble corrosive materials carried from boilers in entrained condensate are all too often responsible for container corrosion, discoloration and damage to out side enamels or lithography during retorting. The presence of these materials is usually due to faulty practices in boiler operation such as excessive use of boiler compounds, high concentrations of salts in the boiler water and high water levels. All of these practices are conducive to "priming," the main cause of liquid carryover. Periodic draining and flushing of all steam lines with fresh water will usually prevent an accumulation of corrosive materials which may have been carried over into the steam lines.

Steam Production

Boiler or steam generator capacities are often listed in terms of boiler horsepower. This value may be defined in terms of the ability of the unit to change approximately 34 pounds of water at 212°F to steam at 212°F. It has been common practice to rate a boiler on the basis of 10 square feet of heating surface per boiler horsepower. With improved firing methods it was found that a boiler could develop considerably more than "rated capacity." The rating of boiler horsepower according to heating surface has therefore become obsolete, although it is still used occasionally with reference to standardized boilers of lower capacity. The most common term used today is the number of pounds of steam per hour that the boiler will produce under a specified set of conditions.

Steam generation equipment may be classified into two general types, firetube and watertube boilers. These in turn may be obtained in several different styles. The firetube type either in the horizontal return tubular or Scotch marine styles are the most commonly used, particularly in seasonal operations and primarily because of its lower initial cost. The firetube type is generally operated at rather low pressures usually not over 150 psi. The watertube type is usually used in larger installations involving year-round operations and where large amounts of steam are required and where very high boiler pressures can be used. Either type may be operated at something over their nominal rated capacities, the degree of overload depending upon design, setting, fuel and other factors. One advantage of firetube boilers is the large water storage capacity. Because of this feature, wide and sudden fluctuations in steam demand are met with little change in pressure. Watertube units on the other hand are capable of considerably higher overloads both continuous and intermittent. The knowledge that boilers can be operated in excess of rated capacity quite often results in an installation that is undersized, as too much faith is placed in the possible overload and not enough consideration is given to loss of efficiency over extended use, and expansion of operations. Undersizing may occur where steam "generators" or "package" units are used since in general they are compactly constructed for limited space requirements and ease of installation, but usually with no provision for overloads in excess of rated steam production capacity. However, there are some self-contained boiler units designed to provide for considerable overload capacity.

Fuel is an important consideration in selecting a boiler. The choice of fuel usually resolves itself into a matter of economics and no general rule appears to be applicable for all localities. In some circumstances a change in fuel and/or firing method can increase steam output. Oil and gas firing systems require less attention and maintenance and are cleaner than most coal fired installations. Gas is preferable to either oil or coal if the cost permits, since there is no problem of storage or waste disposal.

Another problem is that of single versus multiple installations. This question almost always arises whenever new steam plants are being considered. This will require careful analysis of the intended operations particularly with respect to possible demand variations. Usually if over 6,000 pounds of steam per hour are required to handle peak demands, with very low off-season demands, multiple installations should be considered. If a boiler should fail in the case of dual installations, it is usually possible to operate with one boiler until the failure is rectified. This usually requires very careful juggling of certain operations, but it can minimize the losses which may result from a complete shutdown.

A careful analysis of the cannery steam requirement and the operating requirements of individual units by competent personnel is necessary to ensure the selection and installation of a steam plant which will most efficiently supply an adequate amount of steam, at the time needed. A well engineered steam plant can contribute much in reducing production costs.

Consumption Demand

In determining the size of capacity of boiler installations, one must give consideration principally to the peak demands of various operations and with respect to the number and frequency of occurrence of these peak demands. These peaks may differ greatly from operating demands and it is imperative that an adequate steam supply be available to preclude the possibility of affecting the efficiency of other operations which may be going on at the time of peak demands. Besides having ample boiler capacities, steam lines adequate for the peak demands of the various operations must be installed and with proper insulation to protect against undue amounts of condensation.

The installation of steam traps where possible will help in reducing the demands on boilers since they allow for utilization of all the potential heat in the steam. It is very important that traps be properly sized to insure adequate condensate removal.

Probably the best example of the wide variance between the peak demand and operating demand is in the retorting operation. Peak demands for retorting occur during the venting period when the air is being expelled from the retort. At this time the peak may vary between 2,500 and 6,000 pounds per hour for a standard three or four crate retort, depending upon the size of the steam inlet line. Peaks for 1-inch inlets will reach a rate of approximately 2,500 pounds, 1¼-inch 3,500 pounds, 1½-inch 4,500 pounds, and 2-inch approximately 6,000 pounds per hour. Roughly one-fourth to one-half of the total steam required per charge is used during the venting period and will vary depending on the venting cycle required for each installation. The peak demand drops off rapidly to an operating demand of 100 to 150 pounds per hour after the vent valve is closed and the retort reaches operating temperature. The average steam consumption for a full three or four crate retort for processes up to 60 minutes will vary from 250 to 300 pounds of steam or approximately 6 pounds of steam per case of 24 No. 2 cans. There is no significant difference in the requirements of three and four crate retorts or between hot and cold retorts. Because of the high peak demands for individual retort come-up, care must be exercised in timing these operations in order to prevent undue demands upon the steam generating system. Unless the system is over-burdened by regular operating demands, an efficient generator will usually recover after such demands with no appreciable pressure drop at the boiler. In order to minimize the effect of pressure drops in boilers operating at near peak capacity, it is sometimes desirable to install a reducing valve in the boiler header thus allowing the boiler to be operated at something greater than line pressure. This acts as a reserve steam supply.

Other equipment such as blanchers may have rather high peak demands at the start when it is necessary to heat up a sizable amount of water to blanching temperature. Peaks of this nature offer no problem as they are usually met before actual plant operations start.

Steam Requirements of Products

The following steam consumption values are based on actual flow meter measurements made in canneries during normal operations. All values are expressed in pounds of steam per case of product.

Product	Pounds of Steam Per Case Preparation	Retorting	Total
Asparagus Cuts, No. 2's Cannery A	16	7.8	23.8
Asparagus Cuts, No. 2's Cannery B	13	5.1	18.1
Asparagus Cuts, No. 10's	17.2	6.7	23.9
Corn, whole grain in brine, No. 2's	3	6.3	9.3
Corn, cream style, No. 2's	10	6.6	16.6
Peas, No. 2's	8.3	6.5	14.8
Apple Slices, No. 10's	......	....	32
Applesauce, No. 10's	......	....	20

The steam consumption values listed above for the retorting operations are quite consistent for the products involved, with an average of 6.5 pounds of steam per case of 24 No. 2 cans. This has proven to be a good figure for estimating steam requirements and is also consistent with the total of 250 to 300 pounds of steam per retort.

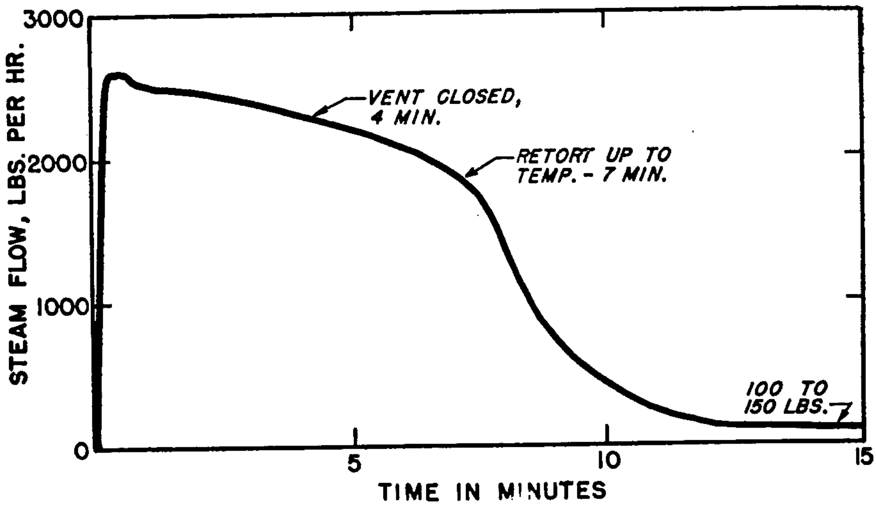
Steam Requirements–Unit Operations

The approximate steam consumption requirements based on either measured or reported values for some of the more significant operations follow:

Unit Operation	Peak Demand *(lbs. per hour)*	Operating Demand *(lbs. per hour)*	Av. lbs. steam used per case
Retort			
1-inch steam inlet	2500	100– 150	6.5
1¼-inch steam inlet	3500	100– 150	6.5
1½-inch steam inlet	4500	100– 150	6.5
2-inch steam inlet	6000	100– 150	6.5
Continuous pressure cooker	6000	1000–1500	3.5–4.0
Open kettle (212°F.) processing 60 min.	2000	100– 200	2–5
Blancher, reel	3000	1000	5–6
Blancher, tubular	3000	1200	5–6
Flash sterilizer T.J.–30G./min.	950	750	1.8
Open kettle concentration tomato puree–1.045	6000	5000	49 (6–10's)
Brine heating (60 to 200°F.)	....	....	3
Double batch mixer, cream style corn	1800	750	3
Exhaust box, steam (4' x 20')	500	500	3 (6–10's)

All values are expressed in pounds of steam per hour with averages based on a case of 24 No. 2's or as otherwise indicated.

Typical Steam Consumption Curve for Retorting



Once unit demands are determined, a complete analysis of the various operations must be made with respect to the occurrence and timing of these demands. With this information available, it is a relatively simple matter to sum up all of the peak and operating demands which occur at any given time, and the highest figure will then be the maximum demand for the operation. From this requirement the steam generating and distribution systems can then be determined. At this point engineering assistance should be obtained to review the consumption data, determine the best type of boiler and fuel to be used, and to plan an adequate distribution system. Some consideration should also be given to possible future expansion of canning operations so that provisions can be made for additions to the steam plant. All too often installations are made with no consideration of future needs. Too much consideration may be given to utilizing all possible capacities from overload with the mistaken thought that the cost of the next size boiler would be prohibitive. This may result in inadequate steam supplies and expanded production costs. It is far better to play safe and oversize the steam plant.

Estimation of Steam Requirements

In estimating steam consumption requirements for a cannery, knowledge of the demands, both peak and operating, for each individual piece of equipment using steam is important. If this information is not available some means of estimating these demands is necessary. The heaviest demands usually occur during retorting operations particularly during retort come-up. This is especially significant if two or more retorts are coming up at the same time. Continuous processing systems tend to eliminate excessively high peak demands, thereby resulting in a lower boiler rating requirement.

The following table lists the approximate flow of steam at various line pressures through several size orifices discharging directly to atmospheric pressure.

FLOW OF STEAM THROUGH AN ORIFICE

	Size of Orifice						
Steam Pressure psi gage	1/8 in. (.01227 sq. in.)	3/16 in. (.02671 sq. in.)	1/4 in. (.049 sq. in.)	3/8 in. (.110 sq. in.)	1/2 in. (.19635 sq. in.)	3/4 in. (.4418 sq. in.)	1 inch (.7854 sq. in.)
5	7	20	58	80	145	315	580
10	10	30	52	120	216	480	850
20	14	40	76	175	316	690	1230
30	20	50	100	215	384	840	1510
40	26	60	125	260	450	980	1780
50	33	70	150	300	520	1125	2050
60	38	85	175	345	590	1270	2330
70	44	95	200	390	660	1415	2600
80	50	105	225	430	730	1560	2880
90	56	115	250	475	800	1700	3170
100	61	130	275	520	870	1850	3450

Steam flow given in pounds per hour.

All flows are listed in pounds per hour. This table may be used for estimating the steam requirements for non-standard operations such as exhausting, blanching and direct steam injection heating. From the size and number of holes from which steam discharges in the equipment and knowing the line pressure, peak demands may be estimated. The same tables can be applied to 1/8 to 1-inch steam supply lines to various units if the line is relatively short.

ENERGY CONSERVATION

The canning industry can apply its experience in conservation and re-use of water to a stepped-up energy-saving effort. Methods canners can use are given in Bulletin 36-L (1974) issued by the National Canners Association. The U.S. canning industry used $74 million dollars worth of various fuels in 1971 for processing fruits and vegetables, specialty products and seafoods. Using the steps outlined in the publication some canners have reported savings of 10 to 15 percent in energy requirements.

The energy conservation methods were developed by a team of production and engineering managers from the food canning industry and its equipment suppliers. Following is the information presented in NCA Bulletin 36-L, pointing out possible savings in housekeeping operations, boiler and power plant operations, agricultural practices, raw product handling and cleaning, processing equipment and operations, transportation, and equipment maintenance.

Introduction

The canning industry recognizes that maximum efficiency in the utilization of all energy consuming utilities is a moral obligation of the food producing community to merit the high priority of energy resources assigned to food manufacturing and distribution.

Important also is the fact that there is a practical business necessity for individual companies to remain competitive in the face of spiraling energy and other costs.

In canning plant operations, energy conservation and water conservation are closely associated. In many canning plants, water conservation programs have been an important part of management considerations for several years. The necessity to focus managerial efforts on intensive campaigns to conserve energy resources is relatively new to most companies. Until recently, energy costs in this country were not sufficiently high to repay intensive conservation efforts on the part of food plant operators.

The single responsibility of the canning industry that overrides all others in importance, however, is: *The Safety and Wholesomeness of Canned Food Products.* All utility conservation efforts must be reviewed in the light of this responsibility.

ORGANIZATION FOR UTILITY MANAGEMENT

No utility conservation program can be any stronger than the commitment of the corporate management to see that the job gets done. Establish conservation goals. One canner reports close to a 15% reduction in energy (power and fuel equivalent) expenditures per unit of production already achieved as a result of a corporate group program.

Organize a management team to originate, coordinate and evaluate utility conservation ideas.

Several corporations have assigned energy and utility conservation responsibilities at the vice president level.

Some multi-plant operators have organized their utility conservation teams from representatives of the various divisions, plants or profit centers within the corporation. Energy conservation ideas are exchanged in a committee approach and then each division within the company is given the responsibility for an energy conservation program within that division, setting up specific goals that each can hope to achieve. Utility managers and energy and water conservation coordinators can be appointed at appropriate plant or division levels to supervise conservation programs in all operating divisions.

Quality assurance or quality control personnel must have the final word in evaluating any utility conservation ideas affecting canned product safety or wholesomeness.

Install an effective system of metering utility input at the plant and devise an appropriate feed-back system for reporting and evaluating utility conservation results.

Utility management priorities utilized to deal with a fuel emergency in several corporations may be summarized as follows:

First Priority

Emergency fuel allocation considerations–make whatever fuel allocation decisions may be necessary to stay in production.

Second Priority

Enforce good housekeeping utility conservation measures. Do immediately whatever can be achieved by altering plant practices to conserve utilities and motivate personnel to participate actively in such steps.

Third Priority

Engineering considerations for the expenditure of capital money to recover utilities—utilization of waste heat and reuse of water.

Fourth Priority

Evaluate opportunities for alternate fuel systems in the event that this should become necessary.

UTILITY AUDITS

To measure effectiveness in utility conservation programs the following information elements are necessary:

1. An accurate metering of utility (electric power, fuel, water) input. All forms of energy input must be converted to appropriate common units; kilowatt hours, BTU's, fuel oil equivalents, etc.
2. Evaluation of canned food production in terms of utility usage per standard or actual case.

To assess the effectiveness of utility conservation measures, data on water and energy usage must be expressed in terms of suitable production units. Utility costs are likely to fluctuate rapidly and for this reason, cost figures are not a convenient yardstick for evaluating the success of conservation measures. Utility costs per case are, unfortunately, likely to show increases even in the face of substantial achievements in increasing the efficiency of utility utilization.

If total energy input is to be evaluated, the audit should cover all energy sources utilized by the company, preferably before the start of the conservation program and at relatively frequent intervals thereafter. This will of course include electric power from meter records, gas utility purchases from meter records, purchases of bottled gas for any in-plant uses, power plant (boiler) fuels of all types, vehicle fuel purchases including truck, automobile and forklift truck operations required in production, and metering of water use for unit operations. Local utility companies may be contacted for accurate meter and energy conversion factors. Average energy equivalent factors are available from handbooks and other sources.

HOUSEKEEPING OPERATIONS: A GOOD PLACE TO START

Lighting

1. All lighting, except for security and safety lighting, should be turned off when not in use. Time switches for interior lighting and photo-cell switches for exterior lighting should be considered.
2. Although adequate lighting for work areas is essential, peripheral areas should be surveyed with the objective of removing bulbs or fluorescent tubes or replacing with bulbs of lower wattage. Phase out unnecessary lighting in office, corridor, cafeteria, inplant, ingredient receiving and storage, and warehouse areas.

3. Use fluorescent, mercury or sodium fixtures where feasible rather than incandescent since they deliver more light per kilowatt hour, respectively. The initial cost is higher in the same order.

4. Install separate, independent lighting circuits and switches where practical to allow localized lighting of work areas.

5. Replace age-yellowed prismatic panels and louvers. Up to 15% improvement in lighting efficiency may be realized.

6. Consider the policy of group, instead of singular, bulb replacement. Lamp output drops up to 15% after two years.

7. Keep lamps, fixtures and reflecting surfaces clean. Post instructions for operating, cleaning and maintenance of light fixtures and audit for custodial compliance.

Heating

1. Office temperatures should be held to no more than 68°. The use of personal electric heaters is wasteful and should be permitted only under extreme conditions. Keep windows free of obstruction for maximum sunlight and keep windows and doors closed. Consider time clock controls to reduce heating after working hours.

2. Plant and warehouse temperatures should be reduced to the lowest temperature in which employees wearing jackets or sweaters can work efficiently.

3. Maintain clean filters on heating and ventilating equipment.

4. Control the make-up air temperatures and quantities in ventilation systems to the minimum.

5. Warehouses which are only intermittently used should be heated to no more than 40°, while 50° F dry-bulb temperature may be sufficient for finished product warehousing.

6. Obvious air leakage should be eliminated by weatherstripping or by other means. Expenditures for extensive insulation and weatherstripping are not always justified in existing buildings. They should be considered in severe climates.

7. Particular attention should be paid to keeping warehouse doors closed to the maximum extent possible consistent with necessary lift truck traffic. Consider split canvas curtains, air curtains and self-closing doors.

8. Construct entrance ports for large doors leading into plant or office. Install seals at truck loading doors.

9. Consider use of carpeting to reduce floor heat loss.

10. With the implementation of heating savings in buildings heated by steam, it may be practicable to operate a boiler only intermittently in order to maintain the minimum necessary temperature. This should include consideration for night time and weekends, and shutting down of all boilers not required for other uses during mild weather.

Water

1. The supply of water requires energy for production, transportation, purification, and waste treatment. Consequently, saving water will save energy and dollars as well.

2. Stop leaks and use automatic-off faucets or shut off water lines left running for no reason.

3. Consider reducing the temperature of hot water for personnel use and turning water heating down or off on weekends.

4. Make a thorough study of the use of processing water with the objective of accomplishing necessary washing and cooling without waste and with the maximum reuse of water. Consider the installation or extension of the counterflow use of water and the reuse of empty can wash water for washing of filled and sealed cans.

5. Check the frequency of clean-up needed tor maximum efficiency and use high pressure–low volume for quick cycle clean-ups.

6. Consider clean-in-place systems for specific applications.

Electric Power

1. A systematic review of the entire electric power system should be made. Adequate instruments, e.g. ammeters, voltmeters, RPM indicators should be used.

2. Loose drive belts waste power.

3. Overloaded motors waste power in the form of heat and are obviously undesirable because the unnecessary stress will shorten the service life of the motor. All driven equipment should be well lubricated and checked for free operation to minimize frictional loading and reduce risk of overheating.

4. Underloaded motors waste power. They also lower the power factor which can increase billing charges. Improving the power factor will definitely save energy.

5. In most areas, improvement of the power factor by installation of capacitors cannot be justified on a savings basis. The possibility should not, however, be summarily written off.

6. Reducing the maximum demand load by possible shifting of heavy loads to off-load hours will be reflected in lower power bills but will not in itself save energy except in the unlikely instance where the facility is a major customer of a small utility. It may be of value in an overall area electrical shortage.

7. Do not operate standby equipment when the primary equipment can carry the load and turn off electric motors during non-production periods.

Steam

1. Check steam distribution systems from boiler to end-of-line for losses and remove unused or unnecessary steam piping.

2. Repair valve seats to prevent steam leakage, such as into empty retorts and steam kettles.

3. Repair valve packing in controllers and hand valves to prevent steam leakage.

4. Install and maintain steam traps at the end of steam manifolds at retort installations. It may be worthwhile to pipe the steam exit of the traps to a return line to be used to warm make-up water for boiler operations. Similar arrangements may be practicable in some agitating cooker installations.

5. Keep heat transfer surfaces clean.

6. Keep insulation in good condition.

7. Check condensate return system for malfunctioning traps and leaks in the line.

8. Check for excessive steam vented to atmosphere.

9. Watch usage of heated make-up water; excessive usage will indicate losses in the system which should be corrected.

10. Periodically check steam-using equipment, e.g. blanchers, heat exchangers, exhaust boxes, cookers, retorts, and kettles for operation at the proper temperature and the absence of leaks.

11. Reduce operating steam pressures during production periods to a minimum suitable to the demand.

BOILER AND POWER PLANT OPERATIONS

1. Continued training of boiler operators is essential, particularly in full load operation with alternate fuels.

2. Each boiler installation should include an on-stream gas analyzer to measure directly the volume by percent of oxygen and combustibles in flue gases. If there is excessive air in the flue gases, the boiler fuel settings should be corrected immediately.

3. Each installation should have and use a stack gas temperature monitoring device.

4. Instrumentation and auxiliary equipment must be kept in first-class condition.

5. Boilers should be frequently checked for cleanliness and condition, including:

   a. Dirty burners—both air and fuel passages; replace inefficient burners.
   b. Cracked or loose refractory, especially around drumheads.
   c. Loose linkages on stack dampers and secondary air controls.
   d. Lag in boiler control leading to improper oxygen content in flue gas.
   e. Clean internal and external surfaces of drums and tubes.

6. Watch for unequal loading when boilers are operated in parallel on a common pressure controlled fuel line.

7. Reduce boilers to low pressure on weekends or during low or non-production shifts, using the minimum pressure and number of boilers possible.

8. Use waste steam or hot water from production operations for preheating boiler make-up water or use clean, wasted hot water for boiler make-up. Some expamples:

   a. If a vent blow-down manifold is used at retort installations, a water line installed in the manifold could utilitize heat from the steam for preheating boiler make-up water. The vent manifold would have to be sized large enough to meet requirements in the Good Manufacturing Practices regulation 21 CFR 128b, substracting the area occupied by the water line.
   b. If cans are cooled in the retort, suitable piping arrangements can be made to utilize the initial hot water for boiler make-up water.
   c. In water processing of glass containers the steamwater mixture from the pressure regulating valve overflow could be used for boiler make-up water or for heating boiler make-up water.

9. Investigate alternate sources of boiler fuels, such as filtered compressor lubrication oil or re-cycled motor oil.

10. Check steam distribution system for losses:
    a. Keep insulation in good condition.
    b. Check condensation return system for malfunctioning traps and leaks.
    c. Check for excessive steam vented to the atmosphere.
    d. Monitor use of treated make-up water; excessive use indicates losses needing correction.

AGRICULTURAL PRACTICES

Since energy use is one of the cost factors considered in growing and harvesting crops, the farmer naturally tends to optimize its use. However, it may be worthwhile for individual growers to calculate an energy balance around each of their crops to determine which unit-operations consume the most energy. After they have these figures, they may find a unit-operation or two that can be modified to reduce the amount of energy consumed and yet achieve the same results.

The first step involved in determining the energy balance is to determine the total amount of energy used to produce and harvest the crop. The second step would be to list all of the unit-operations involved.* And the third step would be to calculate the amount of energy used in each unit-operation, making sure that the sum agrees with the total. A critical examination of where the energy is being consumed may identify points where reductions can be made without sacrificing total efficiency or yield.

Every grower should be applying at least the following principles in his everyday operations:

1. Timeliness–refers to all aspects of agriculture. Each unit-operation should be performed at the optimum time to achieve maximum efficiency per unit of energy input.

2. Improved engine maintenance–fuel economies of up to 10% can be achieved in well-tuned engines.

3. Operation of machinery at or near rated output results in most efficient conversion of fuel energy to mechanical energy.

4. Implements should be selected to fully load tractor engines. If this is not possible, tractors should operate in high gears and be throttled back to desired speed.

5. Machines should be properly weighted to minimize wheel slippage.

6. Changes in cultural practices–
    A. Minimum tillage–in many crop/soil situations energy reductions may be achieved. This concept requires higher level management skills and

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*Unit-operations to be considered for energy balance technique
1. Tillage–incorporation of residue of previous seasons
2. Seedbed preparation
3. Planting
4. Application of selected pesticides
5. Tillage–weed and water control
6. Harvesting
7. Reduction of crop residue
8. Application of fertilizer
9. Application of irrigation water
10. Crop drying, where appropriate

appropriate research to determine optimum tillage requirement. This concept may require compensatory energy input in the form of herbicides.

B. Reductions in chemical fertilizer application–
   a. better timing to reduce number of applications.
   b. on some crops, actual amount applied per application may be reduced, but appropriate research should be conducted and higher management skill may be required.

7. Increased use of diesel engines which are more efficient than equivalent gasoline powered engines.

8. Any factor which increases yields increases the efficiency of the application of energy.

9. Improvement in irrigation water use to optimize crop production without using excess amounts.

10. Transporation–taking proper management steps to insure that the most efficient mode is utilized.

A long range help to energy conservation is proper land use planning. Policies which encourage use of fertile, easily tilled, relatively level land for crop production and less productive land for housing, business, transportation and manufacturing will improve energy efficiency in agriculture.

Overall, practices which foster high yields per production unit will result in efficiency in energy use.

RAW PRODUCT HANDLING AND CLEANING

1. Review product receiving, cold storage, handling and cleaning methods to determine whether engineering changes are feasible for energy or water conservation.
2. Utilize gravity flow wherever possible.
3. Determine the need for unit operations which may be obsolescent because of production line changes (e.g. multiple product inspections).
4. Schedule full and continuous production loads whenever possible.
5. Minimize water use consistent with proper cleaning and investigate dry cleaning possibilities. Reuse water by counterflow where possible.
6. Determine whether reduction of wash water temperature is practicable.
7. Avoid preheating blanching equipment before necessary.
8. Investigate alternative blanching procedures and avoid unnecessary cooling of blanched product.
9. Use insulation to minimize heat loss.
10. Institute an incentive system to encourage suggestions by operating personnel.

PROCESSING EQUIPMENT AND OPERATIONS

1. Adequate venting of air from thermal processing (retorting) equipment and continuous free steam flow from the bleeders is essential for safe processing. *Do Not Attempt Steam Conservation By Decreasing Retort Venting or Closing Retort Bleeders.*
2. Avoid preheating and venting continuous retorts before the time indicated as necessary by the production schedule.
3. Consider insulation of retorts to prevent loss of radiant heat and minimize employee heat exposure.

4. Check air equipment for leaks to reduce compressor time. Compressed air is a costly utility. Inspect and review all plant operations to locate and eliminate unnecessary or wasteful uses.

5. If economically possible use heated water or venting steam for regeneration, plant heating, etc. (e.g. in continuous cooker coolers the atmospheric cooler water might be cycled to the pressure cooler and then cleaned for boiler make-up use).

6. For vacuum production mechanical pumps have a higher initial cost but are more economical to operate than steam-jet ejectors.

7. Product to product heat exchanger regeneration may save energy in aseptic canning operations.

TRANSPORTATION

Detailed energy conservation considerations involved in the transportation and distribution of the finished canned product are beyond the scope of this book. All companies own some fleet vehicles, however, and many may have substantial private trucking operations. These must not be overlooked in any conservation efforts.

1. Set up a record system to measure "miles per gallon" for each vehicle. Establish a procedure to take action (tune up, etc.) whenever a vehicle's mileage performance falls below a predetermined point.

2. Conduct a "purchasing specification" analysis of both tractors and trailers to avoid:

   a. Under or over powering of tractors (horsepower, axle and transmission).

   b. Unrealistic trailer capacity requirements.

3. Consider advantages of diesel versus gasoline.

4. Make use of route engineering to reduce empty miles (improvement in productivity). This can involve—Sales Policy with respect to order minimums, incrementals, delivery frequency, back hauls, "trade offs" with reduced level of customer service.

5. Extend use of rail and piggy-back where possible.

6. Emphasize "driver education"—speed limitations and shifting speeds. Consider programs for driver evaluation. The AAA says 40% can be lost through inefficient practices.

7. Review and update maintenance programs on a regular basis.

8. Maintain close relationship with truck and engine manufacturers for industry related fuel savings ideas and methods.

EQUIPMENT MAINTENANCE

Preventive maintenance of all cannery equipment is essential in achieving peak efficiency. While this is undoubtedly already a major feature of cannery operation it must be doubly emphasized at this time.

The preceding sections provide a suggested check list relating to utility conservation, and proper implementation of the procedures suggested requires that all equipment be maintained through a continuous, preventive program. This will not only ensure efficient operation but will also preclude costly and energy consuming production losses caused by equipment breakdown and motor failures

EQUIPMENT

There is no such thing as standardized canning plant construction or equipment. The unit system has not been developed so that by the increase of certain increments the capacity may be changed. The machines are not balanced as to size and capacity so that each step bears a relation to that which preceded or is to follow. The designing has been done with reference to a mechanism to accomplish a certain result rather than as a unit in a system. The closest approach to a unit system is to be found in pea canning, where 6 viners, 1 cleaner, 1 washer, 1 grader, 5 picking tables, 1 blancher, 1 filler, 1 exhauster, (but only if No. 10 or gallon peas are packed), 1 closing machine, 4 retorts, 1 hoist, with the minor accessories, make a nearly balanced line. On other lines it is a matter of taking the best that is offered and timing the different units to work as nearly alike as possible. The safest and most economical plan is to call upon the canning machinery manufacturer, submitting your problem; have him submit lay-out plans and the most up-to-date equipment. Placing the responsibility upon him will save you money, worry and mistakes.

Equipment Requirements

The kind, the amount, and the arrangement of equipment are determined by the items, the sizes of cans and the quantities of each product to be canned. Some items such as corn, peas, green and wax beans, lima beans, require special equipment, not suitable for use with other products. Such vegetables as beets, carrots, and sweet potatoes require relatively simple equipment which is common to most canneries using pressure cookers. Spinach needs special washers and special blanchers. On the other hand, asparagus requires but little special equipment. The dry pack items, pork and beans, kidney beans, hominy, etc., require soaking equipment not used for canning fresh products. The "cyclone" and finisher, together with evaporating equipment, are required for tomato pulp (puree) and for tomato paste. The "cyclone" is also needed for pumpkin and squash and the finisher is also usually employed. Peaches and apricots need the lye peeler and the blancher. The filling tables, syrupers, exhaust boxes, closing machines, and cookers are the same. The outstanding exception among the fruits is the olive, and that requires special equipment throughout. Milk, meats, and soups are specialties which can not be combined with other lines of canning to any advantage.

While it is possible to can limited quantities of most items without much special equipment, it should be noted that adequacy of equipment is essential to efficient plant operation, and the lowering of costs.

The catalogs of the various manufacturers of canning machinery might lead one to think that very elaborate outfits were an essential. Certain pieces are necessary to do a special kind of work, others are economical as part of a unit, and still others may be desirable in order to reduce the number of laborers. The amount of equipment should be determined in a measure by the quantity of intelligent labor available. It is surprising how much can be done in some factories where the machines are arranged to be kept in continuous operation, compared with others of much larger size, but which work only at intervals.

There are certain qualities which should be in every machine; first, that it shall perform the function for which it is designed; second, that the work shall be done cleanly and that the machine may be easily cleaned; third, that the machine shall be of as simple design as possible, and of such sturdy construction as to need few repairs, and fourth that it be economical in operation. There has been a very marked improvement in nearly all machines in these particulars. One of the most serious objections at present is rating them at such large capacity that they have to be operated at maximum speed to take care of the production. Each machine has its maximum capacity for correct performance. Crowding any machine beyond this point causes trouble. It is far better to attain maximum output by avoiding breakdowns. This can be done through careful attention to the adjustments of the machines and intelligent operation at all times.

The leading manufacturers of canning machinery have prepared factory plans or designs of the most up-to-date machinery and showing their proper arrangement which they will gladly furnish on request, and which you should have. The layouts given herein cover particular products, as you will note. They are the latest and best obtainable and show a vast improvement in efficiency and sanitation over earlier methods. These designs will serve to give you the right ideas as to layout in an up-to-date cannery or other food producing plant, and you cannot afford to attempt competition without using the best obtainable for the purpose.

In recent years approved designs for food conveyors and for rotary blanchers have been established, in which are incorporated the latest improvements with respect to efficiency of operation, ease of cleaning, etc.

Small Plant

There are products which require much hand work in their preparation and only the simplest mechanical equipment, and these may be packed in a small unit. These products include:

Apples	Asparagus
Peaches	Kraut
Pears	Sweet Potatoes
Berries	Carrots
Tomatoes	Spinach

By providing a roller grader, apricots and plums, and possibly others, may be added to this list.

The equipment for packing 200 cases or more per day for most of these lines is:

3 preparation tables	1 open cooker
1 filling table	1 cooling tank
100 twelve-quart pans	1 hoist
1 tank and sprays for washing	18 retort crates
1 scalder and blancher	1 40-H. P. boiler
1 kettle	1 engine and pump
3 50-gallon tanks for brine or syrup	Scales
1 exhaust box	Trucks
1 closing machine	Buckets
3 retorts	Small Accessories

The tables should be 15 feet long, 39 inches wide, with the top pitched from front to back, and a shelf placed below to receive the refuse buckets.

The closing machine should be of the automatic type for placing the cover on the can and feeding it into the sealing mechanism. These have a capacity of 20,000 or more cans per day, but under no circumstances is it advisable to feed them by hand where the output exceeds forty cases per day.

The boiler capacity should be large, as it requires far more steam for pumping and heating water than is ever indicated by consulting the catalog of supplies.

A small group of about twenty persons will pack a surprisingly large amount of material in a season, provided they are well directed and work steadily. By adding to the number on the preparation and filling tables a considerable increase in the volume can be effected without adding to the equipment.

Large Plant

In the larger factories, the use of tables with sinks, conveyor systems for both the product in preparation and in the can, graders, syruping machines, and continuous cookers all add to the speed and volume which can be handled in a given space. The output is increased from two to five cases per person employed. Such equipment should be laid out by an expert engineer after all the facts have been ascertained.

SANITARY CONSTRUCTION OF FOOD PLANT EQUIPMENT

Certain general considerations that must be taken into account with reference to materials to use for equipment are the following:

Parts made of cast iron should not be used in contact with food. Galvanized iron is not acceptable either, as zinc wears out and it eventually causes a problem. Monel metal, which is an alloy of copper and nickel, is acceptable as it is quite resistant to corrosion, but it should not be used for products which are subject to discoloration by traces of copper that may be incorporated into the food. Stainless steel is the most desirable material, No. 316 stainless steel being more corrosion resistant than No. 304. Aluminum is a good heat conductor, but it is quite readily corroded by fruit acids and by alkalies used for cleaning. Copper, brass, or bronze parts are not recommended. If used, they should be scrupulously clean, as copper corrodes even in contact with air, forming film of soluble copper compounds which dissolve into foods. This is undesirable both from public health and product quality standpoints. Glass is very good, but it should not be used when breakage is possible. Glass is used also to coat metals, but it presents a risk in that it may chip and expose metal surface, which is undesirable. Rubber is suitable for materials used for conveyor belts, but canvas is preferable.

Equipment should be constructed without angle corners, as these are difficult to clean. If not clean they can be source of food spoilage microorganisms that may contaminate food. There should be no dead end pipes, as these are usually difficult to clean. Pipes should be joined with sanitary-type joints as these have no crevices and are easy to disassemble and clean.

To clean equipment use high pressure water jets in combination successively with alkaline and mild acid detergents and other surface activators. Water temperature should not be above 140°F, as higher temperatures cause coagulation of food proteins which then are deposited as a film on equipment surfaces. Sanitizing agents, like iodophores, may be added to water but this is not considered the best way to sanitize equipment. Almost all of the sanitizing materials are ineffective in the presence of organic matter.

FOOD PLANT EQUIPMENT DESIGN

The following are desirable characteristics of sanitary food plant equipment:

1. All machine parts must be designed for quick dismantling and reassembling - some merely be removing and replacing a nut or wing screw by hand. It is also best to construct these parts of light weight material so that they can be easily handled for cleaning.
2. Surfaces of equipment in contact with food must be easily cleaned and readily accessible for inspection.
3. Open seams in cooking kettles, mixers, blenders, storage vats, and filling machines must be eliminated.
4. Surfaces of equipment in contact with food must be smooth and continuous. Rough spots and crevices must be avoided.
5. All junctions - particularly pipelines and ducts - must be curved or rounded. Cooking kettles, storage tanks, holding vats, and similar units must have long curves at the juncture of the bottom and side walls instead of sharp corners.
6. All machine parts in contact with food must be accessible for hand-brush cleaning.
7. Dead-end areas in all machines must be eliminated.
8. Metals like lead, antimony, and cadmium must not be used in fabricating equipment. Copper or copper-containing alloys are not recommended.
9. Stuffing boxes or glands in which food might accumulate and decompose should not be used.
10. Pipe fittings must have a sanitary thread, and threaded parts must be accessible for cleaning.
11. Plug-type valves should be used.
12. Run-off valves should be installed as close as possible to mixers, kettles, vats and tanks.
13. Coupling nuts on piping and valves must have sufficient clearance, and must be easily taken apart.
14. Food products should be protected from lubricants and condensates - moisture condensing on ceilings may pick up dirt and peeled paint, later to drop into open cooking kettles or holding vats.
15. Mixing blades should be welded to the drive shaft, or both should be in one piece. Shaft and blades should be removable from mixer, and at a point above the surface of the product.
16. Machine parts in contact with food should be constructed of non-corrosive metal.

17. Equipment like kettles, certain mixers and holding vats, and storage bins should have sectional covers, which are free from seams, hinges, crevices, and heads in which dirt might collect.
18. Drive shafts must be sealed so that lubricating grease does not work its way into the food.

Sanitation Criteria for Pipes, Valves, and Pumps

Increased interest has been shown in basic criteria for piping, valves, and pumps in food plants. These recommendations, made by National Canners Association, Committee for Sanitation of Canning Equipment, apply to the design, materials and construction of piping, valves, and pumps handling food products. They may also serve as guides for new developments in materials and design.

Materials:

1. Stainless Steel or Similar Corrosion Resistant Metal

a. Selection of alloys should be based upon the manufacturer's recommendations for the type of food and use.

b. The surfaces must be free of cracks and crevices and all welds must be ground smooth.

c. Sheet or plate metal should be at least a No. 2B mill finish or equal, properly applied, depending upon usage.

d. Sanitary tubing should be a No. 4 finish or equal I.D.

2. Glass

a. Heat resistant glass piping of a borosilicate type should be used.

b. Glass should not be used where unusual stress may occur.

3. Cast Iron, Cast and Forged Steel and Nickel Alloys

a. Selection of alloys and surface finish to be determined by exact usage. Food contact surfaces must be smooth and non-porous.

b. Interior surface to be free of cracks, crevices and recesses.

4. Plastics

a. Choice of plastic material will depend upon type and temperature of the product.

b. Abrasion resistant and shatterproof plastics should be used.

c. Heat resistance and softening of the material should be determined before use.

d. It should not contain any constituents that may migrate to the food, such as free phenol, formaldehyde, etc.

e. Fiberglass reinforced plastics should not be used as food contact parts where it may become broken or abraded.

5. Gaskets and Packing Materials

a. The exact material to be determined by the type of product and temperature to be used.

b. All should be non-porous, non-absorbent, and non-toxic. No lead or zinc fillers should be used in gasket materials.

c. Types may include neoprene synthetic rubber, Buta N synthetic rubber, or Teflon plastics.

6. Alternate Materials

a. Additional materials which prove to be equally satisfactory from the standpoint of sanitation and product protection would be acceptable.

b. Laboratory and pilot plant use should establish that a material is cleanable, resistant to product, and does not create a food additive problem.

Design and Construction:

1. Piping

a. Piping, fittings, and connections should be of ample diameter to permit easy cleaning.

b. All interior surfaces should be smooth, continuous, free from pits and threads, and contain no open or rough seams.

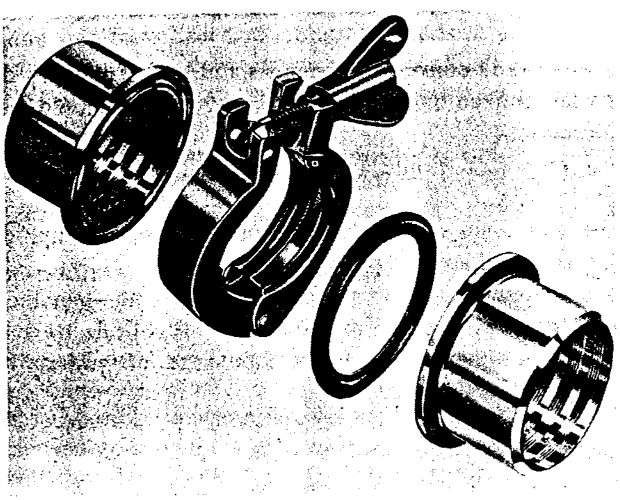
c. C.I.P. (permanent) systems shall be of corrosion resistant stainless steel, heat resistant glass or equivalent.

d. Any permanently installed piping system must be provided with a return cleaning line to allow complete recirculation of detergent and sanitizer solutions during cleanup.

e. Where inspection openings are needed in C.I.P. systems, use sanitary elbows with C.I.P. fittings.

f. Inspection openings are usually recommended at all changes of direction of pipe. However, with heliarc welded pipe combined with proper cleaning and sanitizing, this would not be necessary.

g. Pipes or chutes using gravity flow should be readily demountable for cleaning and inspection. Where possible, easily removed covers should be used.



CLAMP-TYPE FITTINGS

Easy to disassemble, made of corrosion resistant #304 or #316 stainless steel.
(Courtesy of Sta-Rite Industries, Inc.)

h. Sharp corners should be avoided and no dead ends, blind tees, or inside threads are permitted.

i. All permanent joints of metal piping must be continuously welded and be free of cracks or rough surfaces.

j. All other joints shall be ground or gasketed (with a self-positioning gasket) to form a sanitary joint.

k. When cleaning glass pipe, do not use materials that will scratch or etch the surfaces.

2. Pumps.

a. Heads must be readily removable for cleaning and inspection with all product zone parts conforming to material requirements under Part C.

b. Sanitary type fittings should be used on the head to connect to piping.

c. All bearings should be located outside of product zones, and if adjacent thereto, must be constructed with a readily removable seal at the entrance of the shaft.

d. Impeller, rotor and/or valve assemblies must be readily removable for cleaning and inspections.

e. Pumps must have no internal by-passes in the head which are not self-draining. The pump head itself should be self-draining.

f. Pumps and solution tanks for C.I.P. pipe line systems should be corrosion resistant and pumps should be sized to give a velocity of not less than five feet per second through the largest pipe or fitting.

g. In C.I.P. systems, product pumps should be designed to have all parts which contact the product completely self-cleaning, including seal.

h. Packing gland assemblies must have a readily removable seal and should be constructed of material as described under Part C, 5, (Gaskets).

i. Exterior surfaces should be easily cleanable.

3. Valves

a. All valves in food conveying systems should be of sanitary design without pockets or recesses and completely self-draining. Valves should be self-flushing during normal operation.

b. Internal by-passes should be avoided, their usage to be determined by ability to be self-draining.

c. All run-off or drain valves should be placed as near equipment as possible to prevent pockets or dead areas in piping.

d. Gaskets, diaphragms, stem packing and other non-metallic parts should conform to the description of gasket materials under Part C, 5.

e. Lubricants for valves and plugs should be of sanitary quality, non-flammable, odorless, and non-toxic.

Placement and Installation:

1. Piping

a. Should be installed a minimum of 2 feet away from walls and ceilings to provide access for cleaning and painting.

b. Piping should be a minimum of 8 inches above the floor to provide for cleaning.

c. All sections must be provided with adequate hangers or supports to prevent sagging or buckling at the joints.

d. All hangers or supports should be easily cleanable and should not provide a collecting surface for dust or soil.

e. All pipe should be installed to permit self-draining. A minimum slope of 1/8 inch per foot should be provided.

f. Systems should be designed to operate with all pipe lines full. Partially filled lines are a sanitation hazard.

g. All pipe lines should be identified as to use or material carried.

h. Cold pipes should be insulated to prevent condensation. Insulating materials should be inert and impervious to water and not likely to peel, flake or break.

i. Consideration must be given to the possibility of electrolytic corrosion in the placement of piping as well as in the selection of clamps, hangers and where piping attaches to electrically driven devices.

2. Pumps

a. Should be installed away from walls and other equipment sufficiently to permit dismantling and cleaning.

b. Pumps installed on floors should be on a solid base which is sealed water tight.

c. In mounting give consideration to minimum clearance for cleaning.

CARE AND USE OF TEMPERATURE CONTROLLERS AND RECORDERS

Controllers and recorders for processing should be installed so that they can be easily read and free from heat and vibration. Bends in the thermal tube should be kept to a minimum, and sharp bends or kinks avoided. The tube should be protected so that it will not be damaged. Only qualified persons should make repairs on the thermal or control mechanisms.

The pen arm, as it moves up and down, should follow along the arc of the time intervals on the chart for proper interpretation of the temperature curves. If it does not, the arm is not the correct length. This can be easily adjusted on most controllers.

The temperature recording pen is connected to the thermal system, but as installed does not necessarily indicate the correct temperature. It must be standardized against the retort mercury thermometer. The adjustment is made by means of a screw which changes the position of the pen arm in relation to the thermal pointer. When the recorder is not in use, the pen should be left resting on an old chart, because most pens are plated and the plating may wear off and ruin the pen if it is allowed to rub on the face plate.

At the start of a day's operations, the clock should be wound and the chart placed in the proper position, so that the pen indicates the time of day. The air filter should be drained daily to remove oil or water.

The greatest problem connected with pneumatic controllers for processing is the maintenance of a clean, dry air supply at a constant pressure. Moisture, oil, corrosive liquids, or foreign particles carried into the pneumatic system from the air supply will eventually cause trouble. Pneumatic controllers operating with clean air require little cleaning and maintenance.

A separate supply system should be provided for instrument operation only. The compressor should be large enough to provide air at a low capacity rating. An overloaded compressor is more likely to pump oil. The system should be designed to supply at least one cubic foot of free air per minute per instrument. If a separate compressor is not feasible, a separate distribution system should be provided for the air-operated instruments. Adequate filter systems should be installed to supply clean, dry, oil-free air.

The main supply line should be at least one-half inch pipe of corrosion-resistant material such as copper or brass. Black iron pipe is not suitable. The main should be sloped to drip lines. It has been estimated that 80% of all pneumatic instrument troubles are caused by *dirty air*.

EQUIPMENT CORROSION

Corrosion is the wearing away or alteration of a metal or alloy either by direct chemical attack or by electro-chemical reaction. A prime contributor of corrosion is water in contact with metal. Other corrosion agents are oxygen, carbon dioxide, chlorine compounds, and acids, both organic and inorganic.

Galvanic Corrosion

Galvanic corrosion may occur when two different metals in contact are exposed to a conductive solution such as tomato juice or pineapple juice. The electro potential existing between different metals serves as a driving force to pass current through the corrodent. This potential difference between metals can be measured and is arranged in what we call a gallvanic series. The wider apart the two metals are separated in a series, the greater the likelihood that galvanic corrosion will occur. Therefore, to minimize galvanic corrosion, similar metals should be used wherever possible; or in case dissimilar metals are used, they must be separated by either insulation, paint or coatings. When dissimilar metals are used, a sacrificial anode may be employed, such as magesium or zinc, which will corrode faster than the other two dissimilar metals.

Stress corrosion

Stresses in metal, either by internal or external pressure, will create paths within the grain of the metal which tend to corrode more readily under certain conditions. It is important to utilize preventative methods, such as stress relieving or selecting a more resistant material. The presence of nitrogen in iron or steel tends to make metals more prone to stress corrosion cracking under certain tensile strengths and in certain environments. If steel contains aluminum, there is a better resistance to stress corrosion. It is important here then that periodic maintenance and inspection be utilized to detect this type of corrosion.

Erosion corrosion

When there is a movement of a corrodent over a metal surface the mechanical wear and corrosion is called erosion corrosion. This may occur at high velocity conditions, such as in heat exchangers, and it may be minimized by going to larger pipe sizes and streamlining the bends to minimize impingement effects. Erosion or corrosion can occur on pumps, impellers, agitators and piping and can be avoided by selection of more resistant material or by protective coatings.

Cavitation and fretting corrosion are special forms of erosion corrosion. Cavitation is caused by rapid formation and collapse of vapor bubbles on a metal surface. The high pressures thus produced can deform the underlying metal and remove protective films. Fretting corrosion occurs when metals slide over each other causing mechanical damage to one or both surfaces. This has been shown in bearings and may be minimized by using harder materials to reduce the friction.

Crevice corrosion

Any time that scratches or crevices develop at joints, bolts and rivets, local corrosion may occur in the crevices. The environment plays an important role, since the presence of moisture, acidity, or lack of oxygen will influrence the degree of corrosion. It is important therefore in designing equipment to minimize crevices and take proper steps so that surfaces may be kept clean in order to minimize this.

Pitting corrosion

This type of corrosion is evident in the interior of walls of a pipe in which holes are formed. This pitting may continue at a very slow rate, then all of a sudden result in failure that may not be visible. The selection of a metal and the cleanliness of the surface are very important factors in avoiding this problem. Another type of corrosion is exfoliation, but this differs from pitting in that the attack has a laminated appearance and is sub-surface corrosion. There is usually a flaky and sometimes blistered surface, and this again can be minimized by removal of one element (zinc) in an alloy.

Recommendations

Once the various types of corrosion are understood, means for detecting and controlling the condition play a very important role. Sometimes selection and material or operating conditions are uncontrollable, but is important to diagnose the reason for corrosion. Preventive maintenance can do much to help minimize corrosion, since it sometimes is impossible to alter the temperature and environment that the metals are subjected to. Therefore recognizing the situation and using protective coatings, as well as controlling acidity and temperature within certain ranges, are deemed worthwhile. The downtime and replacement parts that fail because of corrosion can be very costly, and adequate records of when to replace parts as well as preventive maintenance are important considerations.

Since water is used in rather large quantities in most processing plants, it is important to have test analysis on the water so that one may predict to what conditions certain metals would be exposed and where this would retard corrosion or increase it. Selection of certain inhibitors in the water that are approved will retard some forms of corrosion and extend the life of the material used.

By understanding corrosion and taking preventive maintenance as well as controlling corrosion, one may extend life of equipment and reduce the cost shutdown due to corrosion failure.

SANITATION

Sanitary conditions are important in food plants not only because of public health and good appearance factors, but also because sanitary practices contribute to better quality and better keeping characteristics of processed foods. Present day science and technology afford the food processor more effective and economical means of processing food under better sanitary conditions than was possible some decades ago. Some of the information included in this section on Sanitation has been taken from the excellent book by M. E. Parker and J. H. Litchfield titled "Food Plant Sanitation." The reader is referred to that publication for more details.

The above mentioned publication defines sanitary practices in the food industries as the systematic control of environmental conditions during the transportation, storage, and processing of foods in such a manner that their contamination by microorganisms, insects, rodents or other animal pests, and by foreign chemical materials, can be prevented. In general, sanitary practice begins on the farm, or on the fishing vessel at sea, and does not end until the food is served to the consumer either in a restaurant or in the home.

CANNED FOODS AND PUBLIC HEALTH

With reference to the sanitary characteristics of processed foods shipped in interstate commerce, federal laws require that they be totally free of pathogenic or disease causing mecroorganisms. Pathogenic bacteria, as well as yeasts and fungi, are characterized by very little heat resistance. The sterilization process given commercially canned foods of any kind–fruits, vegetables, meats, and seafoods–are more than sufficient to kill any pathogenic bacteria that might be present in the can at the time of sterilization. In addition, several of the preliminary canning operations are effective either in physically removing or killing microorganisms present in foods. The washing and peeling operations contribute to physically remove microorganisms, while blanching aids in killing as well as removing bacteria, yeasts, and molds. The sterilization process, preliminary operations, and proper personnel, plant, and equipment sanitation all combine to make canned foods totally free of disease-causing microorganisms. It is proper to mention here that U. S. canned foods also have a remarkably good record in reference to botulism, which, incidentally, is not considered a disease but an intoxication.

SANITATION OF CANNING PLANT PERSONNEL

Good health of the plant personnel is important. Testing of the personnel for communicable diseases would be desirable but it is not practicable. Persons with wounds or with respiratory diseases should not be allowed to work in food processing plants. Persons known to have had communicable diseases should be tested before they are allowed to work to have assurance that they are not carriers.

Food processing plant personnel that must handle food with their hands must, whenever possible, wear rubber gloves. Hands of humans contain microorganisms that can be classified in two groups: transient flora and resident flora. The resident flora is found in hair follicles, and skin crevices, while the transient flora is mainly on the skin surface. The transient flora is removable with detergents, while the resident flora is more difficult to remove and requires the use of disinfectants aided by brushes with stiff bristles. The disinfectants that are used are mainly phenols, iodophors, and quaternary ammonium compounds. Among the phenols, hexachlorophene is used and has some residual bacteriostatic effect for up to 24 hours. Phenols are most effective against Gram positive bacteria, and not effective against Gram negative bacteria. Salmonella are gram negative. The effectiveness of phenolic disinfectants is reduced by thc presence of food residues on the hands, therefore it is recommended to wash the hands first with a detergent to eliminate food particles. Iodophors are active against most Gram positive and Gram negative bacteria, but should be used at pH 5.0 or below. Quaternary ammonium compounds also act against Gram positive and Gram negative bacteria, but their action is neutralized by soaps, food materials, and hard water. However, they are more active in the pressure or organic matter than any other class of bactericides. With these disinfectants soft or softened water must be used, and hands should be washed first. If a detergent is used for the preliminary wash, it must be removed by thorough rinsing of the hands with abundant water.

It is recommended that the hands washing area for plant personnel be located in an area where the supervisor is able to observe whether the hands are properly sanitized. Plenty of hot water of at least 150°F should be provided to mix with cold water. Soap and towels should always be available. As a disinfectant, a solution of 200 parts per million (0.02 percent) of a quaternary ammonium compound is recommended. This solution should be prepared fresh three times during each 8 hour work period. After washing hands with soap and warm water and rinsing, hands should be dipped in the quaternary ammonium compound solution. It is difficult to get the plant personnel in the habit of following that hand washing and sanitizing procedure, but it is an effective way of preventing infection of food with bacteria that are present on the hands, and it helps prevent the infection of wounds, which could cause infection of food with pathogenic bacteria.

CONTROL OF MICROORGANISMS

The preservation of food products depends upon preventing contamination by spoilage-causing microorganisms before, during, and following processing operations. In addition, certain microorganisms are the causative agents of food-borne infections and intoxications and may render a food product contaminated with them unfit for consumption.

In canning, it is important to consider raw materials as potential carriers of processed food spoilage microorganisms. Heat resistant bacteria present in soils can cause "flat sour" and other spoilage of canned vegetables if soil is not thoroughly removed by washing. Fresh fruit may be contaminated with molds. If the infected portions are not removed during the early stages of processing, both the final product and the air inside the plant may become heavily contaminated, and infect subsequent lots of sound fruit. Mold growth, in addition to indicating that the product is not sound, can communicate off-flavors and odors to the raw products, which can be carried into the processed food.

Shipping containers for raw fruits and vegetables should be thoroughly washed and treated with a fungicide to prevent spread of mold infections.

The sanitizing agents more commonly used in food plants can be classified in three groups: quaternary ammonium compounds, halogens, and phenolic compounds.

The quaternary ammonium compounds are excellent bactericides. They have the following general characteristics: effective against Gram-positive and Gram-negative bacteria; stable as a dry powder, as a concentrated paste or as a solution at room temperature; stable to heat over a long period of time; colorless and odorless; soluble in water; non-corrosive to common metals; surfaces may be rendered bacteriostatic for some time after treatment; and are non-irritating to the skin in commonly used dilutions. They show their greatest antimicrobial activity in the pH range above 6.0. In addition, they are more active in the presence of organic matter than any other class of bactericides. However, they are incompatible with soaps and many detergents. Hard waters, and waters containing iron reduce their bacterial effectiveness.

Of the halogens, chlorine and its compounds are the most important agents for disinfecting and sanitizing food processing equipment and utensils, and for disinfecting water supplies. However, in recent years iodine preparations have been accepted to an increasing extent for use in sanitizing operations. The major use of chlorine in food plant sanitation is in the chlorination of process and cooling waters to prevent accumulation of bacteria. Calcium hypochlorite and sodium hypochlorite are important sources of chlorine in food plant sanitation. They are more costly than elemental chlorine on an available chlorine basis, but they are easier to apply in small quantities for sanitizing food processing equipment and utensils. Temperature, pH, and amount of organic matter present exert a marked influence upon the bactericidal effectiveness of hypochlorite solutions.

The iodophors is another group of halogens. They contain iodine. The advantages of iodophors are rapid bacterial action in the acid pH range in hard or cold waters; readily mixable with water in all proportions; non-toxic to humans in ordinary concentrations; non-irritating after repeated contact with the skin; non-corrosive; possess wetting, detergent, and penetrating properties; and do not impart stains nor objectionable tastes and odors. In addition, the intensity of the color of the solution provides an indication of the concentration of the iodine present, and therefore of its activity. On the basis of these properties, the iodophors are being used to an increasing extent in food plant sanitation.

Phenolic compounds are used only to a limited extent in food plant sanitation. The most important applications of these agents are in the formulation of antifungal paints and antifungal protective coatings. In general, phenolic compounds are only slightly soluble in water which limits their use in food plant sanitation.

EQUIPMENT CLEANING PROCEDURES

The following suggestions for equipment cleaning procedures should result in reduction of bacterial growth on equipment and minimized contamination of food being processed:

1. Before cleaning dismantle or open the equipment as far as possible.
2. Disconnect lines where possible or open cutouts to avoid washing debris from one piece of equipment to the next.
3. Remove as much waste as possible with brush, shovel, broom or other appropriate tool.
4. Rinse surfaces to be cleaned with water to remove food residues.
5. Clean surfaces with hot water with an added detergent specifically formulated for the removal of a particular type of soil. Use cleaning aids such as high pressure or brushes to remove tenacious deposits.
6. Complete the cleaning by thoroughly flushing with hot water to remove detergent residues, and finally rinse with cold water to cool equipment below 80°F.
7. Allow equipment to drain and air-dry.
8. Do not depend on high pressure steam to sterilize equipment; in many instances the steam spreads contamination by blowing it from crevices and cracks onto equipment which has been cleaned.
9. Before resuming operations, sanitize equipment by rinsing or spraying the equipment with a chlorine solution which contains 100 to 200 parts per million.
10. Sanitize in same manner water pipes used for recirculating wash water and for pumping peas, corn, etc., as well as brines and syrup.
11. Avoid contamination of equipment by spatter from floors or from contaminated equipment.
12. Keep hoses used for rinsing equipment off the floor.
13. Make sure that water used for brine, syrups and for cleaning is free from contamination. Water storage tanks must be frequently drained, cleaned and sanitized so as to eliminate bacterial build-up.
14. Thoroughly back-wash and sanitize regularly water filters and water softeners. Bacterial build-up by accumulation and actual growth is very common in this equipment.

15. Eliminate dead ends in water pipes, brine and syrup pipes and pipes used for transferring foods from one place or equipment to another.
16. Eliminate dead ends in flumes, sharp curves, bad solder and welded joints.
17. Provide in-plant chlorination and maintain a chlorine residual of 1ppm in the plant water supply. Provide controls so the chlorine content can be increased to 25 ppm or higher during cleaning operations.
18. Eliminate scale from the surfaces of pipeline blanchers, water pipes and equipment surface. Such deposits may harbor thermophiles and other types of microorganisms.
19. Keep viners clean so as to reduce the contamination of peas and lima beans.
20. Pea boxes, bins, etc. must be in good repair and washed after each trip to the plant. Rinsing the boxes and bins with a chlorinated final rinse is recommended.
21. Clean daily and sanitize corn huskers and cutters.
22. Replace wooden husker and cutter bins with metal ones, and clean and sanitize daily.
23. Keep cooling tanks clean and chlorinate cooling tanks or canals. Satisfactory chlorine residual is 2 to 5 ppm.
24. During canning and freezing operations periodically rinse equipment, conveyor belts, picking tables with water to prevent accumulation of debris, thereby physically removing large numbers of microorganisms.
25. During a breakdown, rinse off equipment and cool it down below 90° F. so as to arrest bacterial growth.
26. During short period shutdowns keep washers, dewatering screens, blanchers, and similar equipment running, and cool down to below 90° F.
27. Use only sugar, starch, salt, spices which have been tested and approved by a reliable laboratory for canning or freezing purposes.

SANITARY FOOD PLANT BUILDINGS

The surroundings of food plants should be neatly landscaped and well drained. Buildings should be preferably oriented east-west to avoid excess heating by sun during the summer.

Building foundations should be brought to 2 or 3 feet above ground to prevent rodents from coming in the building.

Areas in the plant where different operations are performed, should be separated by partitions. Areas where there is equipment that needs to be hosed, should have tiled walls. Walls in the warehouse should be smooth and light colored. All wall junctions should be round and not square angled to facilitate cleaning.

Ceilings in processing areas and warehouse should be washable. Joints should be sealed. This helps prevent moisture condensation on ceilings, which could be a nuisance and cause product contamination

The processing, cooling, warehousing, and packaging areas should be separated. Doors and windows should be screened with 16 mesh screen to protect against entrance of insects and rodents. All rooms should be adequately ventilated to help prevent condensation of moisture. Dressing and wash rooms, and clothing storage-rooms should be located outside the processing area.

Certain work areas of industries of certain types need to be fitted with air intakes that bring in air free of microorganisms. This is especially true with industries in which contamination with Salmonella may be a problem.

There should be no connections between the potable water system, and non-potable water.

A basic part of adequate sanitation is large, well ventilated, and fully equipped toilets for both men and women employees. Most states and cities have regulations about this matter that should be considered in designing the building.

LIGHTING

Good industrial lighting is a production tool that markedly affects employee accuracy, efficiency, and morale. It has been proved that good lighting—that is, a properly designed and maintained lighting system— results in more and better production through faster, more accurate seeing.

Lighting systems that are tailored to a budget, rather than to the best recommended lighting practices, often prove inadequate. Frequently the results are poor product quality and wasted effort, the cost of which may exceed, by many times, the cost of a good lighting system.

When footcandle levels exceed the recommended minimum levels shown in the following tables, better seeing conditions are provided, more efficient use of plant equipment results, and manufacturing costs are reduced. Where production quality standards are high or where a high degree of precision is required, lighting levels substantially higher than those recommended below are suggested.

The following are the levels of illumination recommended by the Illuminating Engineering Society.

Canning and Preserving	Footcandles on Tasks
Initial grading of raw material samples	50
Tomatoes	100
Color grading (cutting rooms)	200 (a)
Preparation	
Preliminary sorting	
Apricots and peaches	50
Tomatoes	100
Olives	150
Cutting and pitting	100
Final sorting	100
Canning	
Continuous belt canning	100
Sink canning	100

Canning and Preserving — Continued		Footcandles on Tasks
Hand packing		50
Olives		100
Examination of canned samples		200 (f)
Container handling		
Inspection		200 (a)
Can unscramblers		70
Labeling and cartoning		30
Dairy Products		
Fluid milk industry		
Boiler room		30
Bottle storage		30
Bottle sorting		50
Bottle washers		(f)
Can washers		30
Cooling equipment		30
Filling: inspection		100
Gauges	(on face)	50
Laboratories		100
Meter panels	(on face)	50
Pasteurizers		30
Separators		30
Storage refrigerator		30
Tanks, vats		
Light interiors		20
Dark interiors		100
Thermometer	(on face)	50
Weighing room		30
Scales		70

Meat Packing	Footcandles on Tasks
Slaughtering	30
Cleaning, cutting, cooking, grinding, canning, packing	100
Candy Making	
Box department	50
Chocolate department	
Husking, winnowing, fat extraction crusing and refining, feeding	50
Bean cleaning, sorting, dipping, packing, wrapping	50
Milling	100
Cream making	
Mixing, cooking, molding	50
Gum drops and jellied forms	50
Hand decorating	100
Hard candy	
Mixing, cooking, molding	50
Die cutting and sorting	100
Kiss making and wrapping	100

Bakeries	Footcandles on Tasks
Mixing room	50
Face of shelves (vertical illumination)	30
Inside of mixing bowl (vertical mixers)	50
Fermentation room	30
Make-up room	
Bread	30
Sweet yeast-raised products	50
Proofing room	30
Oven room	30
Fillings and other ingredients	50
Decorating and icing	
Mechanical	50
Hand	100
Scales and thermometers	50
Wrapping room	30

Offices	Footcandles on Tasks
Cartography, designing, detailed drafting	200
Accounting, auditing, tabulating, business machine operation, reading poor reproductions, rough layout drafting	150
Regular office work, reading good reproductions, transcribing handwriting in hard pencil or on poor paper, active filing, index references, mail sorting	100
Reading or transcribing handwriting in ink or medium pencil on good quality paper, intermittent filing	70
Reading high-contrast or well printed material, tasks and areas not involving critical or prolonged seeing such as conferring, interviewing, inactive files, washrooms	30
Corridors, elevators, escalators, stairways	20 (k)

Notes:

(a) Can be obtained with a combination of general lighting plus specialized supplementary lighting. Care should be taken to keep within the recommended brightness ratios. These seeing tasks generally involve the discrimination of fine detail for long periods of time and under conditions of poor contrast. The design and installation of the combination system must not only provide a sufficient amount of light, but also the proper direction of light, diffusion, color, and eye protection. As far as possible it should eliminate direct and reflected glare as well as objectionable shadows.

(f) Special lighting such that (1) the luminous area shall be large enough to cover the surface that is being inspected and (2) the brightness be within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low brightness in which the source brightness is the principal factor rather than the footcandles produced at a given point.

(k) Or not less than one-fifth the level in adjacent areas.

CANNERY WASTE DISPOSAL

DISPOSAL OF FRUIT AND VEGETABLE PROCESSING WASTES

The satisfactory disposal of waste waters from processing of fruits and vegetables is a complex problem. Stream conditions arising from the discharge or organic wastes have led to the passage of stronger pollution control laws and greater activity by control agencies. Sportsmen and civic groups interested in outdoor recreation are increasingly critical of stream quality. There is a growing realization that water is community property; that use of water from streams and from underground sources is a privilege which ought not to be abused, and that water "borrowed" from the community supply should be returned in a condition and by a method which does not result in damage or inconvenience to the community. State and Federal authorities are more and more exacting in their demands and each plant must provide adequate solution.

Failure of a food processor to plan accordingly could eventually result in excessive costs for treatment or disposal of his waste water. If there are any serious difficulties the problem should be referred to a competent Sanitary Engineer.

The U.S. Environmental Protection Agency (EPA) has issued standards for the quality of stream water and the strength of an effluent which can be legally discharged into it. The EPA is primarily a regulatory agency, with responsibilities for establishing and enforcing environmental standards, within the limits of its various statutory authorities. The agency shares many of its enforcement authorities within the states.

One of the major areas of EPA activitiy affecting food processors is the Federal Water Pollution Control Act amendments of 1972. The new law creates a program with three major elements: uniform nationwide standards; enforceable regulations; and a permanent program based on effluent limits and geared to specific goals. The Act was designed to "restore and maintain the chemical, physical, and biological integrity of the nation's waters".

Industry must meet the standards set up, regardless of the plant location and regardless of the capacity of the stream to absorb the wastes without unreasonable damage. In some instances this approach has resulted in an unjust hardship to industry.

FACTORS TO BE CONSIDERED IN WASTE DISPOSAL PROBLEMS

The high organic strength of the usual cannery wastes is the principal reason for the difficulty encountered in their disposal. Raw untreated cannery wastes consist of small particles and sometimes discarded whole pieces of raw product, skins and seeds, suspended in water which carries in solution the juices of the product being canned. As compared to domestic sewage, cannery wastes are unusually high in sugars and starches, and the pollutional strength (BOD) is approximately ten times greater.

The pollutional effect of cannery waste when discharged into a stream will depend on the strength of the waste, the amount of dilution afforded by the stream, and the amount of available oxygen present in the stream water. As long as oxygen is present, decomposition of the organic waste will proceed without occurrence of the stream conditions usually associated with pollution. However, if the strength and volume of the waste water is such that dissolved oxygen disappears from the water, then fish and other forms of aquatic life will disappear. Foul odors will arise from sludge deposits and floating scum.

The goal of the canner in treating his waste flow is to render it suitable for discharge to a stream without causing pollution, or for discharge to a land disposal system without causing a public nuisance, or for acceptance into a sewage treatment plant without penalization because of excessive strength of the wastes.

Initial Survey of the Problem

Before plans and specifications for installation of waste disposal equipment are prepared, the following basic considerations should be investigated in the interests of simplicity of design and economy of operation:

1. Character of wastes. It should be determined if the waste contains materials hazardous or potentially hazardous to public health. It is also desirable to know the concentration of organic solids in the waste and the relative concentration of suspended and soluble solids. An estimate should be made of the amount of suspended solids which could be removed by screening.

2. Waste flow measurements. It is necessary to know the volume of waste water which will require treatment. If possible the flow should be measured (this can be done with meters or weirs or by the bucket-and-stop-watch method), and the average flow determined. The results should be calculated in terms of daily and yearly volumes of wastes.

3. Segregation of highly contaminated waste waters. The possibility should be considered of separating individual waste flows at the point of origin into contaminated waters requiring treatment, and waters with little or no contamination which could be discharged without treatment. The latter group would include can cooling waters, condenser waters, etc. This is an important point in the initial survey of the problem because the volume of waste waters requiring treatment determines the size of the treatment plant. Any reduction in the volume of the waste is an ultimate saving in costs.

4. Study of possible reuse of water as means of reducing waste flow. A study of water usage in a cannery always reveals that more water is used than is necessary. Water reuse in certain operations can substantially reduce the amount of water used, and thus reduce the volume of waste water to be disposed of. This reduction in volume of the waste water may not be accompanied by a reduction in the total organic strength, but will make treatment of the waste more economical and effective. Water reuse, however, ought not to be indiscriminate. Full regard should be given to the fact that improper reuse of water may lead to bacteriological problems.

5. Study of means to reduce amount of gross solids added to waste waters. No unnecessary dumping of solid waste into the gutter should be allowed, because this causes an unnecessary burden on the screens, disintegration of larger solids into particles passing the screen, and leaching of soluble solids from gross solids, resulting in increased organic strength of liquid wastes which must be treated.

6. *Investigation of existing or proposed regulations governing disposal of industrial wastes.* The treatment given must render the wastes acceptable to pollution control agencies if the effluent is to be discharged into a public water course, or suitable for acceptance into a municipal treatment system if this is indicated. If land disposal is the method of choice, then the effluent should be suitable for rapid oxidation and stabilization without causing odor problems.

7. *Selection of treatment and disposal procedures which will accomplish the desired results.* The selection of the method of treatment and disposal should be based on a consideration of the space available for the site of a treatment plant, the effect of climate on the method of disposal, and whether a continuous or batch type treatment is desirable.

8. *Consideration of possible cannery expansion.* Finally, the question should be answered of whether or not the method of treatment selected and the specifications for equipment to carry it out are commensurate with possible long range plans for expansion of cannery operations.

METHODS OF TREATMENT AND DISPOSAL OF WASTES

Primary, Secondary, and Tertiary Methods of Waste Treatment

At present there are two basic ways of treating wastes prior to discharge into streams. They are called primary and secondary. In primary treatment, solids are allowed to settle, or are screened out, or both methods may be used to separate solids from the liquid waste. Secondary treatment, a further step in purifying wastes, uses biological processes to reduce dispersed solids and soluble organic content of liquid waste. Secondary treatment removes up to 90% of the organic matter in wastes by making use of bacteria. Secondary treatment may also include modifying pH of acid waste by addition of alkaline substances to bring it to a value between 6.0 and 9.0.

There are other, more advanced methods of treating wastes which take up where primary and secondary treatments leave off. These more advanced methods are generally called tertiary treatment methods. One of these is the process known as coagulation-sedimentation. In this process, alum or lime is added to effluent as it comes from the secondary treatment. The flow then passes through flocculation tanks where the chemicals cause the smaller particles to floc or bunch together in large masses which are removed by sedimentation. Another tertiary treatment method aims at getting rid of the dissolved refractory organic substances. As the word indicates, this is the stubborn organic matter which persists in water and resists normal biological treatment. By passing the effluent through a bed of activated carbon granules, more than 98 percent of the remaining dissolved organic matter is removed by adsorption. Another tertiary treatment is that of electrodialysis, by which salts from an effluent are removed from water by the action of an electric field. These tertiary methods are, however, quite complex and costly. If cost would be disregarded, it would be possible to supply any quality of water for any reuse from canning or other industrial plant wastes.

EPA Regulations and the Canning Industry

A combination of primary and very good secondary methods of waste treatment is sufficient for the canning industry to comply with present day federal and state regulations, including those of the Environmental Protection Agency (EPA).

As for the future, the EPA has issued two sets of effluent limitation guidelines for the canned and preserved fruits and vegetables industry, one of which is scheduled to become effective as regulations on July 1, 1977, and the other one on July 1, 1983. These EPA guidelines and regulations will require a degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available," by the first date, and the "Best Available Technology Economically Achievable," by the second date. EPA's "Standards of Performance for New Sources" set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives. The proposed regulations require the best secondary treatment technology currently available for discharge into water bodies by July 1, 1977, and for new source performance standards. This technology is represented by preliminary screening and biological treatment.

The recommendation for July 1, 1983, is for the best secondary treatment and in-plant control, as represented by greatly reduced water use, more intensive biological treatment and a final sand filter added to the 1977 technology.

When suitable land is available, land disposal with no discharge is a preferred and usually more economical option which is also sanctioned by EPA.

Removal of Gross Solids by Screening – Primary Treatment

Cannery waste is usually composed of two types of solids, one which is particulate and in suspension, and one which is in true solution. Regardless of the ultimate disposal method, it is desirable to remove by screening as much of the suspended solids as is economically feasible. Failure to screen the wastes causes unsightly conditions in streams due to floating solids from which foul odors may be produced; over-loads lagoons or digesters if this type of treatment is given, and may clog filters and distributors if discharge is to a sewage treatment plant.

Screening is required by most states as a pollution control measure if the waste is to be discharged to public waters, and no intentional maceration, grinding or comminution of gross solids in order to pass them through a regulation size screen is allowed.

Screen Types in General Use– The size, shape, and nature of the solid particles to be removed from the water have a definite effect on the efficiency of the screening operation. Liquid wastes containing fibrous materials are difficult to pass through the finer screens.

Rotary drum screens– These screens are essentially revolving drums covered with a screen cloth varying in fineness from 6 to 60 openings per inch. The liquids and solids enter the drum through an open end. The liquids pass through the screen and the solids are retained on the inside of the cloth. The solids are washed from the cloth by water sprays as they are elevated form the water level and pass over a refuse trough. From the trough the solids are usually removed to a hopper by screw conveyor or bucket elevator.

Vibrating table type screens– These screens are now widely used. Finer screen cloths can be used than would be possible with drum type screens, and the amplitude of the vibrations can be adjusted for differences in the material being screened.

Vibrating screens may be purchased in different sizes. The size and number of screen units needed will depend on the volume of waste to be screened. A 4' x 8' screen will effectively screen 800 to 1000 gallons per minute.

Gyrating circular type screens– These screens have a triple gyratory motion, and while they were designed especially for dry screening and are widely used for separating sand and gravel, grains, and similar products, they also show promise for wet screening operations. Among the advantages claimed are that no special foundation or support is required; that unscreened materials do not spill over and that the three-way vibration allows the use of finer screen cloths.

Disposal of Gross Solids Removed by Screening

Generally, the waste solids from canning are a liability to the canner. Often, however, thought and ingenuity can lessen the costs of their disposal. Sometimes a canner is able to arrange for the solid refuse to be hauled away for animal feed and its value as feed is usually considered payment for the hauling. Also, disposal may be by spreading over farm land, or removing to dry beds from which it is later piled and burned. In some urban areas canners have to pay on a tonnage basis to have the solids removed. In these instances it is desirable to have the waste as dry as possible. Vibrating type screens give drier solids than revolving drum screens. Elevation of the solids to a hopper facilitates loading into trucks and allows considerable de-watering during storage in the hopper.

In some cases cannery waste solids have been successfully turned into dehydrated stock feed.

Disposal of Screened Liquid Wastes

The final volume of screened liquid waste which reaches the point of discharge should be as small as possible consistent with sanitary canning operations.

In some areas certain types of screened liquid wastes are discharged without further treatment. Usually, however, some additional treatment must be given by the canner. The most common methods are as follows:

1. Discharge to municipal sewage treatment systems.
2. Biological treatment.
3. Chemical precipitation of solids.
4. Aeration flotation.
5. Impounding in earthen tanks for purposes of soil absorption or stabilization by oxidation.
6. Land irrigation.

Need for Equalization Tank– Whatever the method of final treatment given, it is desirable to collect the screened wastes in an equalization tank before treatment. Passage of the wastes through such a tank will furnish emergency storage in case of equipment failure, make possible a uniform flow to the disposal area or treatment plant, and allow blending of the fluctuating organic or chemical compositions of the wastes. In the equalization tank provision should be made for sludge removal and, if possible, aeration by some means to prevent septic conditions and odor production.

Discharge to Municipal Sewage Treatment Plant– Discharge of screened raw cannery wastes into a municipal sewage treatment plant is the most desirable disposal method if satisfactory arrangements can be made. However, the seasonal nature of cannery operations and the high pollutional strength of the wastes may cause serious problems.

The average liquid cannery wastes has ten times the strength (BOD) of ordinary domestic sewage. The nature of the pollutants in the cannery waste may also upset normal sewage treatment processes. The sugars and sugar-like compounds in liquid wastes from fruit and vegetable canning require a biological process for stabilization which is not desirable for the complete stabilization of domestic sewage. In some phases of stabilization the two are directly antagonistic. It has been observed that in cases where the volume of domestic sewage is not large enough to give high dilution of the cannery waste, attempts to treat the combined wastes are not effective. However, many canners are discharging wastes to large municipal systems where treatment is completely satisfactory.

In contemplating the discharge of cannery waste to a municipal system the following factors should be considered by both canner and municipality:

The type of treatment process used by the sewage plant. Activated sludge treatment processes are reported to be particularly adversely affected by cannery waste in high concentration.

The volume of cannery waste. The relationship between the volume of cannery waste and the volume of domestic sewage should be considered; that is, whether or not dilution of the cannery waste will be high enough to prevent harm to the treatment process.

The capacity of the sewage plant. The seasonal production of cannery wastes means that consideration must be given to the costs of increasing plant capacity for short-time treatment in relation to the costs of other methods of treatment and disposal.

The type and cost of pre-treatment of the cannery waste. In nearly all cases screening of the cannery waste is necessary, and in many cases pH adjustment of the cannery waste is required before its discharge to the sewer.

The charges which the canner must pay. The charges to the canner for the privilege of discharging his wastes to the municipal treatment system are usually based on one or more of the following considerations:

1. No charge. In some municipal areas authorities and citizens encourage industry because of the employment provided and the disbursement of money through salaries and purchases.

2. Initial payment. An outright purchase of the privilege of waste disposal services may be based on the cost of new equipment required to treat the cannery wastes with no further service charges thereafter.

3. Annual charge for waste disposal services. The charge for service may be the annual payment of a fixed sum which is usually an estimate of the additional expense incurred by the sewage plant in treating cannery wastes.

4. Charges based on water consumption. This basis for charge is probably the one most commonly used. It may be assumed that the amount of water metered into the plant is the amount of water discharged. However, a considerable volume of water is lost through evaporation or addition to the finished product, so a compensating reduction should be allowed.

The charge to the canner may be only that which he pays for the water. If a separate charge is made for disposal services the canner may find it profitable to meter the waste water. In some instances clean waters discharged to the sewer such as cooling and condenser waters are measured and the volume excluded from disposal charges. Ordinarily, disposal charges are calculated on the basis of each 1000 gallons discharged, or a rate schedule of diminishing charge for increasing volume may be used.

Biological Methods for Secondary Treatment of Wastes

Screened liquid cannery waste is amenable to treatment by biological methods, and high degrees of reduction in the strength of the waste can be obtained. However, treatment depending on biological oxidation should be attempted only after investigation of other methods and after careful consideration of the problems involved.

Biological methods are most suitable for treating small volumes of cannery waste. Where a small volume of strong waste can be segregated from the total flow, its treatment by biological methods can give a great reduction in the strength of the composite flow. For example, in pea canning the blanching operation contributes only two to five percent of the total volume of waste, yet removal of the blancher waste reduces the strength of the total waste by 50 to 60 percent.

All types of vegetable and fruit canning wastes will support the growth of bacteria which utilize the sugars and other carbohydrates present. The fermentation of these compounds occurs very quickly and the end-products of the fermentation are compounds of much lower pollutional strength.

Both anaerobic and aerobic digestion of cannery waste have been experimented with, and successful large scale operations have been carried out with each type of digestion. Anaerobic digestion (digestion in the absence of free oxygen) requires more elaborate equipment and more careful attention. For these reasons it may be feasible only in selected cases.

Aerobic digestion of organic wastes is more easily carried out. Usually a two-stage process is planned. In the first stage the fresh screened waste is admitted to a tank where air is continuously diffused into it. This supplies the free oxygen required by the aerobic bacteria in their biochemical action on the organic compounds. The wastes may be detained and aerated in a batch type or continuous flow operation. The efficiency of the process depends on building up in the aeration-digestion tank a vigorous culture of suitable bacteria. Conditions in the tank must be controlled to prevent inhibition of their growth. Good diffusion of air throughout the tank must be maintained continuously. The pH of the waste must be held within a suitable range for growth of the bacteria. Certain types of wastes may require the addition of small amounts of available nitrogen as a food supplement for the bacteria.

In the second stage of the process the waste passes through sedimentation tanks where the flow is made as quiescent as possible in order to promote either flotation or settling of suspended solids.

Chemical Treatment to Remove Suspended Solids – Secondary Treatment

Situations have occurred where removal of suspended solids beyond that accomplished by screening would render the waste acceptable for disposal either to a body of water or to a municipal treatment plant. In some cases chemical treatment of cannery waste has been the most convenient method to accomplish this.

Ordinarily chemical treatment for cannery waste would be undertaken only after careful consideration of the costs, the inconvenience of handling the large volumes of sludge produced, and the failure of the method to give a reduction in strength of the wastes of more than about 50 percent.

Controlled chemical treatment will remove suspended and colloidal solids but will not affect solids in solution. For this reason the degree of treatment obtained will depend on the relative concentrations of suspended and soluble solids. Waste waters high in sugar content cannot be greatly reduced in strength by chemical treatment.

Two types of chemical treatment are used; the continuous flow method, and the fill-and-draw or batch type treatment. Each method requires use of the same chemicals. Although the continuous flow type of treatment will handle larger volumes of water in a given period of time, certain disadvantages are inherent in the process. It is difficult to maintain the optimum chemical dosage in a system where fresh untreated waste enters at one end and treated effluent is discharging at the other. It is also difficult to remove the large volumes of sludge produced.

The fill-and-draw method largely overcomes these disadvantages. With this method screened waters are pumped into one of two or three tanks. When this is full the flow is tuned into a second tank. Agitation is started in the first tank and the proper amount of the first chemical is added. Then half the dosage of the second chemical is added while agitation is continued. After several minutes the remainder of the second chemical is added slowly until a large, heavy floc begins to settle out. When the supernatant liquid is clear it is discharged and the sludge at the bottom is pumped onto sludge drying beds.

Typical dosages for chemical treatment are as follows:

Type of waste treated	Chemical dosage in pounds per 1000 gal. of waste	
	First Chemical	Second Chemical
Pea waste	Lime, 7;	alum or ferrous sulfate, 3.
Beet waste	Lime, 10;	ferrous sulfate, 4.
Corn waste	Lime, 9;	ferrous sulfate, 8; or
	Lime, 6;	zinc chloride, 2 to 6.
Tomato waste	Lime, 4;	alum, 1.

The approximate costs of treating the waste may be calculated if the cost per pound of the chemicals is known.

Aeration-Flotation Process for Removal of Suspended Solids – Secondary Treatment

A method of waste water treatment using the principles of aeration-flotation is being employed by some industries, particularly meat packing and rendering plants. For this type waste the process is reported to be an efficient and economical method for by-products recovery, pollution control, and water conservation.

The theory of aeration-flotation for removal of suspended solids is based on the fact that the amount of gas or air which will dissolve in a liquid is directly proportional to the absolute pressure under which the liquid is maintained. At sea level and a temperature of 70°F water will dissolve approximately two percent of air by volume. At 15 pounds pressure the volume of dissolved air increases to four percent, and at 30 pounds pressure is approximately six percent.

If a waste water supersaturated with air and under pressure is suddenly released into an open tank at atmospheric pressure the volume of air contained above saturation will come from solution in the form of extremely fine bubbles.

These bubbles will attach to particles of suspended matter in the liquid and carry them to the top, forming a layer of "float" which can be removed by skimming.

Chemicals such as lime and alum may be added to the waste water previous to its passage through the aeration-flotation system. Formation of chemical floc in the liquid aids in removal of certain suspended organic solids.

Experiments with the aeration-flotation process have indicated a possible removal of 84 percent of the suspended solids from peach canning waste water, and 63 percent of the suspended solid from pumpkin canning waste water. The use of flocculating chemicals did not increase the effectiveness of the process in the treatment of these two waste waters.

Although the treated effluent was comparatively clear and free of visible suspended solids, removal of the suspended solids did not greatly reduce the strength of the waste. Determination of the five-day BOD on treated and untreated samples showed an average reduction of 17 percent in the case of peach waste and seven percent for pumpkin waste. These results were expected since soluble solids were responsible for the greater portion of the strength of these wastes. However, in situations where removal of suspended solids is indicated, in order to improve the acceptability of a cannery waste for a particular final treatment, the process of aeration-flotation may be considered.

Disposal of Waste to Absorption Ponds or Storage Lagoons – Secondary Treatment

Impounding cannery wastes in storage lagoons offers a means of disposal which eliminates stream pollution and may be less expensive than other methods of treatment. Storage of liquid wastes in earthen ponds allows partial or complete decomposition of the waste, after which the waters can be discharged by controlled flow to a water course or to a municipal plant for further treatment. Where soil conditions are favorable complete absorption into the soil may be obtained. The operational costs of lagooning cannery wastes have been estimated at 0.4 to 0.6 cent per case of product packed.

The lagooning disposal method requires a land area large enough to hold the volume of waste and one that is situated within a distance practical for pumping or piping the wastes. The drainage characteristics of the soil should be studied. Seepage of waste waters should not contaminate underground sources of water supply. Also of importance is proximity of residential areas. Untreated lagoons develop odors which may cause complaint from people living within a radius of a mile.

Odor Control in Cannery Waste Lagoons

As an aid in the prevention of offensive odors from lagooned wastes the lagoon itself should be as large and shallow as the situation will permit. Septic conditions quickly develop in deep lagoons. A waste depth of not more than three feet is preferred, and five feet is the maximum. The growth of weeds and grass should not be permitted in lagoons. Since they are of organic composition, their presence in the lagoon contributes to the odor problem.

In the presence of free oxygen, the starches and sugars of cannery wastes are changed by bacterial action into stable inoffensive compounds such as water, carbon dioxide, nitrates and sulfates. When oxygen is exhausted from the wastes, anaerobic bacteria continue the decomposition with the production of foul-smelling bases such as hydrogen sulfide, ammonia, and mercaptans. This anaerobic condition in lagoons will occur quickly unless fresh waste is continuously added or available oxygen is supplied by other means.

The most satisfactory method for odor control in lagoons is the addition of nitrate of soda, which supplies the available oxygen required for inoffensive decomposition of the wastes. Sodium nitrate of the fertilizer grade is added daily to the fresh waste going into a lagoon in an amount necessary to satisfy 20 percent of the five-day BOD. As an example of the costs of such treatment, pea waste would require a dosage of approximately 200 pounds per 1000 cases packed. At a cost of four cents per pound for the nitrate alone, the costs of the treatment would be 0.6 to 0.8 cent per case of product packed.

Disposal of Waste by Spray Irrigation

In recent years spray irrigation has been used increasingly as a means of cannery waste disposal. In many respects it is an improvement over other methods. It consists of spreading the liquid waste over the surface of the ground by means of a high-pressure sprinkler system. A rate of application is used which produces only minimum damage to vegetative growth and avoids surface erosion and run-off. The system usually requires the following items:

A mechanically operated screening unit.

A collecting tank for accumulation of screened waste.

Stationary screens to prevent clogging of the outlet from the tank.

A pump which develops the required nozzle pressure.

A main line for transporting waste to the irrigation site.

Lateral lines for distribution from the main line.

Self-activated revolving sprinklers.

The land on which to spray.

An actively growing cover crop to aid in absorption and to prevent soil erosion.

With the proper equipment and controlled application of the waste, spray irrigation will completely prevent stream pollution, will not create odor problems, and is usually less expensive than other methods of waste disposal.

Selection of the irrigation site. Of major importance in this method of waste disposal is the selection of land for the irrigation site. Its location must be within practical pumping distance of the cannery. Consideration should be given to the economics of pumping long distances as compared to the costs of disposal by other means.

The topography of the land and characteristics of the soil are important factors to consider. Spray irrigation of land which is not fairly level may not be successful because of run-off and erosion. The possibility of stream pollution from run-off should be considered. Depressions in the surface of the land may cause ponding of the waste water, with odor production resulting from its decomposition.

The amount of land required to dispose of a given volume of waste is determined by the absorption characteristics of the soil, which are, therefore, an important factor in the success of spray irrigation. At present there is no reliable method of predetermining this. Persons having a knowledge of local soil conditions should be consulted.

Importance of the cover crop. When screened raw wastes are sprayed over land without a vegetative cover crop, the rate of application is governed by the rate at which the land will physically absorb the waste. Waste run-off and soil erosion are always serious problems. The importance of a cover crop on irrigated land is quickly apparent when the rates of waste application with and without a cover are compared. For land without a cover crop the amount of waste absorbed is only about 10 to 15 percent of the amount which could be disposed of with a cover crop on the land.

The type of vegetative cover may be determined by what the land is to be used for either during or after the canning season. At some installations cattle are grazed on the vegetative growth during spray operations. The cutting of hay from the land is also a common practice. One cover crop mixture frequently used includes the following:

Mammoth clover	3 pounds
Ladino-Alsac mixture	4 "
Alta fescue	4 "
Red top	3 "
Orchard grass	2 "

This mixture is sowed at the rate of 16 pounds per acre. As dense a cover crop as possible should be provided at the time spraying is to start.

Other considerations. Failure to properly screen cannery wastes is frequently the cause of difficulty in the operation of a spray irrigation system, because the presence of gross solids results in plugging of the spray nozzles. The screen cloth used should not be so fine as to cause flooding over of unscreened wastes. A thorough screening with a coarser cloth would be preferable. Finely divided solids can be sprayed without trouble.

If odors are to be avoided in spray irrigating, the cannery waste must be applied to the land while still fresh. This is a factor to consider in constructing the collecting tank or sump. A tank which has a capacity to provide a long detention time can be a disadvantage since fermentation of the waste will occur. Odors may then be a problem and the lower pH of the waste may cause unnecessary damage to the cover crop. Ordinarily the detention time should not be more than three to four hours.

The costs of spray irrigation. A number of variables are concerned in the final costs of installing a spray irrigation system for cannery waste. It is not possible to make definite cost estimates for particular areas because the amount of land required will depend on the volume of waste water to be sprayed and the capacity of the soil to absorb it. With a good cover crop and average soil absorption capacity, cannery waste can be applied over a given area at the rate of 0.4 to 0.6 inch per hour for a period of time sufficient to give a dosage of three to four inches of waste. One inch per five acres would be equal to 135,750 gallons of waste. One application at this rate would be followed by a rest period of 16 to 24 hours. With average conditions it can be roughly estimated that for each 1.5 million gallons of waste, a cannery would need the use of 20 to 30 acres of land for waste disposal by spray irrigation.

Spray irrigation as a means of cannery waste disposal is now being used by canners throughout the United States and where conditions are suitable, spray irrigation should be seriously considered by the canner confronted with a waste disposal problem.

FOOD LAWS, REGULATIONS, AND STANDARDS

Requirements of the U.S. Food, Drug, and Cosmetic Act

This is a synopsis of the principal requirements of the U.S. Food, Drug, and Cosmetic Act as they apply to foods. It is therefore suggested that manufacturers and shippers fully inform themselves concerning the applicable provisions of the laws and regulations before offering foods for import, or for shipment in interstate commerce. This will expedite their business and prevent needless expense.

The symbols in parentheses are the pertinent sections of the statute itself.

The Law in General

The Federal Food, Drug, and Cosmetic Act prohibits distribution in the United States, or importation, of articles that are adulterated or misbranded. As defined in the law itself, the term "adulteration" has to do with the content of a product (Secs. 402, 501, 601), while "misbranding" includes any statements in labels or labeling that are false or misleading in any particular (403, 502, 602).

The law is intended to assure the consumer that foods are pure and wholesome, safe to eat and produced under sanitary conditions; that drugs and therapeutic devices are safe and effective for their intended uses; that cosmetics are safe and made from appropriate ingredients, and that all labeling and packaging is truthful, informative and not deceptive. Another law, the Fair Packaging and Labeling Act, affects the contents and placement of information required on the package.

Major amendments to the law are designed to protect consumers by preventing violations. Specific products are required to be approved for safety prior to sale or use. Manufacturers submit samples of production batches of color additives to the FDA laboratories for testing and the Agency must certify their purity, potency and safety before they may be shipped. Food additives must be "generally recognized as safe" or proven safe by scientific tests. Residues of pesticide chemicals in food commodities must not exceed safe tolerances set by the Environmental Protection Agency and enforced by FDA. Such premarketing clearances are based on scientific data provided by manufacturers subject to its review and acceptance by scientists for scope and adequacy.

While the legal requirements that must be met are the same for imported and domestic products, the enforcement procedures are necessarily different.

Imports

All imported products are subject to inspection by the Food and Drug Administration of the U.S. Department of Health, Education, and Welfare at the time of entry through U.S. Customs. Shipments found not to comply with the Food, Drug, and Cosmetic Act and its regulations are subject to reexportation or destruction.

At the discretion of the Food and Drug Administration, an importer may be permitted to try to bring an illegal importation into compliance with the law before final decision is made as to whether it may be admitted. Both foreign shippers and importers in the United States should realize that conditional release of an illegal importation to bring it into compliance with the law is not a right but a privilege. Abuse of the privilege, such as repetitious shipment of the same illegal article, may result in denial of the privilege in the case of subsequent importations. Detention is the first regulatory step when a violation is encountered. The shipment has been found illegal and has been "detained," pending final decision as to whether it must be reexported or destroyed or whether is may be conditionally released for bringing into compliance. Any sorting, reprocessing, or relabeling must be supervised by an FDA inspector at the expense of the importer.

Interstate Shipments

Within the United States compliance with the law is secured through periodic inspections of facilities and products, analysis of samples, educational activities, and legal proceedings.

Adulterated or misbranded products found in U.S. interstate commerce may be voluntarily destroyed or recalled from the market by the shipper, or may be seized by U.S. Marshals on orders obtained by the Food and Drug Administration from Federal District Courts.

Persons or firms responsible for illegal products may be prosecuted in the Federal courts and if found guilty may be fined and/or imprisoned. Continued violations may be prohibited by Federal court injunctions. Violation of an injunction is punishable as contempt of court.

When an FDA inspector observes insanitary conditions or practices which may result in violation he leaves a written report of his observations with management. Manufacturers, by correcting these conditions or practices promptly, may bring their operations into compliance. The inspector may also make suggestions regarding other types of compliance problems, but is not an expert in all the technical fields involved in food manufacture. Inspectors will report any voluntary corrective action they witness during an inspection, or which management may bring to their attention.

Seizure is a civil court action against a specific lot of foods in interstate commerce to remove the goods from the channels of commerce. After seizure, the goods may not be tampered with, except by permission of the court. The owner or claimant of the seized merchandise is usually given about 30 days by the court to decide on his course of action. He may do nothing, in which case the goods will be disposed of by the court. He may decide to contest the Government's charges and the case will be scheduled for trial; or he may request permission of the court to bring the goods into compliance with the law. The owner of the goods is required to post a good and sufficient bond to assure that the orders of the court will be carried out, and must pay for FDA supervision of any reconditioning or relabeling.

Many domestic producers are interested in exporting some of their products. If the item is intended for export only, meets the specifications of the foreign purchaser, and is not in conflict with the laws of the country to which it is to be shipped, it is exempt from the adulteration and misbranding provisions of the act (Sec. 801 (d)). It must be labeled "for export" on the outside of the shipping package.

For Further Information

Questions from individuals and firms regarding labeling, controls, formulas, and interpretations of the law and regulations applicable to a particular product or practice may be addressed to the appropriate District Office of the Food and Drug Administration or its Washington headquarters. Requests for comments on proposed labeling should be accompanied by complete ingredients or formula information. The confidentiality of trade secret information is protected by law.

PRINCIPAL REQUIREMENTS OF FOOD LAW

Section 201 (f) of the Federal Food, Drug, and Cosmetic Act defines food as follows:

> The term "food" means (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article.

Below is a synopsis of the principal requirement of the Act relating to foods, in nonlegal language. The symbols in parentheses are the pertinent sections of the statue itself.

Health Safeguards

A food is illegal if it contains a natural or added deleterious substance which may render it injurious to health or unsafe (402) (a) (1) and (2)).

Food additives must be cleared for safety before they may be used in a food, or become a part of a food as a result of processing, packaging, transporting, or holding the food (409).

Raw agricultural products containing residues of pesticides not authorized by, or in excess of, tolerances established by regulations of the Environmental Protection Agency are illegal (408).

A food is illegal if it is prepared, packed, or held under insanitary conditions whereby it may have been rendered injurious to health (402 (a) (4)).

Food containers must be free from any poisonous or deleterious substance which may cause the contents to be injurious to health (402 (a) (6)). Some packaging materials, for example plastic or vinyl containers, may be "food additives" subject to regulations (409).

Colors added to food must be only those established by the Food and Drug Administration as being safe (402 (c) and 706). Unless exempt, colors for use in food must be from batches tested and certified by the Food and Drug Administration (706 (c)).

Confectionery, including candy, must not contain any alcohol, except alcohol not in excess of 0.5 percent derived solely from the use of flavoring extract. It shall not have embedded therein any nonnutritive object unless authorized by FDA. Nonnutritive ingredients (such as food additives) may be used only if they are: (1) safe, (2) serve some practical functional purpose in the manufacture, packaging, or storage of the confectionery, and (3) do not deceive the consumer or violate other provisions of the act.

Sanitary Safeguards

A food is illegal if it is filthy, putrid, or decomposed (402 (a) (3)).

A food is illegal if it is prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth (402 (a) (4)).

A food is illegal if it is the product of a diseased animal or one that has died otherwise than by slaughter (402 (a) (5)).

Economic Safeguards

Food labels or labeling (circulars, etc.) must not be false or misleading in any particular (403 (a)). Labeling is misleading not only if it contains false statements, but also if it fails to reveal material facts (201 (n)).

Damage or inferiority in a food must not be concealed in any manner (402 (b) (3)). Example: artificial coloring and/or flavoring added to a food to make it appear a better grade than it is, as in the case of yellow coloring used to make a food appear to contain more eggs than it actually contains.

A food must not be sold under the name of another food (403 (b)). Example: Canned bonito labeled as tuna fish.

A substance recognized as being a valuable constituent of a food must not be omitted or abstracted in whole or in part (402 (b) (1) and (2)). Example: An article labeled "milk" or "whole milk" from which part of the butterfat has been skimmed.

Food containers must not be so made, formed, or filled as to be misleading (403 (d)). Example: A closed package filled to less than its capacity.

Required Label Statements

Required label information must not only be conspicuously displayed, but it must also be in terms that the ordinary consumer is likely to read and understand under ordinary conditions of purchase and use (403 (f)).

Details concerning type sizes, location, etc., of required label information are contained in FDA Regulation 1.8 b, which covers the requirements of both the Federal Food, Drug, and Cosmetic Act and the Fair Packaging and Labeling Act. Food labeling requirements of the regulation are summarized as follows:

If the label of a food bears representations in a foreign language, the label must bear all of the required statements in the foreign language, as well as in English. (Note–The Tariff Act of 1930 requires all imported articles to be marked with the English name of the country of origin.)

If the food is packaged the following statements must appear on the label in the English language:

1. The name, street address, city, State and Zip Code of either the manufacturer, packer, or distributor. The street address may be omitted by a firm listed in a current city or telephone directory. A firm whose address is outside the United States may omit the Zip Code. If the food is not manufactured by the person or company whose name appears on the label, the name must be qualified by "Manufactured for," "Distributed by," or similar expression.

2. An accurate statement of the net amount of food in the package. The basic units of measure are the avoirdupois pound and the U.S. gallon. The quantity of contents declaration must appear on the principal display panel of the label in lines generally parallel to the base of the package when displayed for sale. If the area of the principal display panel of the package is larger than 5 square inches, the quantity of contents must appear within the lower 30 percent of the label. The declaration must be in a type size based upon the area of the principal display panel of the package (as listed in Regulation 1.8b) and must be separated from other information.

The net weight on packages containing one pound (avoirdupois) or more, and less than 4 pounds must be declared first in total avoirdupois ounces followed by a second statement in parenthesis ( ) in terms of pounds and ounces, or pounds and common or decimal fractions of the pound. (Example: Net Wt. 24 ounces (1½ pounds) or Net Wt. 24 oz. (1.5 lb.)). The contents of packages containing less than one pound must be expressed as total ounces.

Drained weight rather than net weight is required on products packed in a liquid that is not consumed as food, such as olives or pickles in brine.

Net volume of liquid products in packages containing 1 pint or more and less than 1 U.S. gallon must be declared first in total fluid ounces followed by a second statement in parentheses ( ) in terms of quarts, pints, and fluid ounces or fractions of the pint or quart. (Example: 40 fluid ounces (1.25 quarts) or 40 fluid ounces (1¼ quarts)). Volume of packages containing less than 1 pint must be declared in fluid ounces.

Packages 4 pounds or larger or one gallon or larger need not have their contents expressed in terms of total ounces; however, for such packages the contents must be stated in the largest unit of weight or measure, with any remainder in ounces or common or decimal fractions of the pound; or in the case of gallons, the remainder in quarts, pints, and fluid ounces, or decimal fractions of the gallon. The metric system of weight or measure may also be used to declare the quantity, in addition to the English system. If the label of any food package also represents the contents in terms of the number of servings, the size of each serving must be indicated.

3. The common or usual name of nonstandardized foods, or in the case of standardized foods the complete name as designated in the Standard of Identity, must appear on the principal display panel, in bold type and in lines generally parallel to the base of the package as it is displayed. The form of the product must also be included "sliced," "whole," or "chopped" (or other style)–unless depicted by vignette or unless the product is visible through the container.

4. Foods must bear labeling stating the presence of any artificial flavoring, artificial coloring (except butter, cheese, or ice cream), or chemical preservative (403 (k)).

5. The ingredients in a food must be listed by their common names in order of their predominance by weight unless the food is standardized, in which case the label must include only those ingredients which the regulation requires to be declared. The word "ingredients" does not refer to the chemical composition, but means the individual food components of a mixed food. Spices, flavors, and colors may be listed as such, without naming the specific materials. If the presence of a specific expensive ingredient is promoted, additional information such as the percent of the expensive ingredient may be required.

6. The labeling of foods intended for special dietary uses must bear certain prescribed additional information concerning their vitamin, mineral, and other dietary properties which is necessary to inform purchasers fully as to their value for such uses. Regulations that have been issued under this section prescribe the specific additional mandatory label information (403 (j)).

7. Imitations must be labeled as such (403) (c)).

SANITATION AND FILTH

The Food, Drug, and Cosmetic Act is often referred to by the public as the "Pure Food and Drug Act," thus emphasizing one of its basic purposes–the protection of the consuming public from articles that may be deleterious, that are unclean or decomposed or have been exposed to insanitary conditions that may contaminate the article with filth or may render it injurious to health.

In its sanitary provisions, the Food, Drug, and Cosmetic Act goes further than to prohibit commerce in products that are carriers of causative agents of disease. It prohibits the distribution and sale of foods which may contain repulsive or offensive matter classed as filth regardless of whether such objectionable substances can be detected by laboratory procedures or are very likely to be present because of the conditions under which the goods were prepared and handled.

Filth includes contaminating elements as rat and mouse hairs and excreta, whole insects, insect parts and excreta, maggots, larvae, and parasitic worms, pollution from the excrement of man and animals, as well as other extraneous materials which, because of their repulsiveness would not knowingly be eaten or used. The presence of such filth renders foods adulterated, whether or not harm to health can be shown.

The maintenance of sanitary conditions requires extermination and exclusion of rodents, inspection and sorting of raw materials to eliminate the insect-infested and decomposed portions, fumigation, quick handling and proper storage to prevent insect development or contamination, the use of clean equipment, control of possible sources of sewage pollution, and supervision of personnel who prepare foods so that acts of misconduct may not defile the products they handle.

Fumigation of commodities already infested with insects will not result in legal product since dead insects or evidence of past insect activity are objectionable. Fumigation should be employed where necessary, to *prevent* infestation but care is required to prevent build-up of nonpermitted chemical residues from fumigation.

To explain in greater detail what is needed to maintain sanitary conditions in food establishments the FDA has published a set of Current Good Manufacturing Practice Regulations. These tell broadly what kinds of buildings, facilities, equipment and maintenance are needed, and the errors to avoid, to insure sanitation. They deal broadly with such matters as building design and construction, lighting, ventilation, toilet and washing facilities, cleaning of equipment, materials handling, and vermin control. Food firms which do not have copies of these regulations are urged to request them by writing to the Food and Drug Administration.

Many food materials imported into this country are intended for further processing and manufacture into finished foods. This fact in no way relieves such imported raw materials from these requirements of cleanliness and freedom from deleterious impurities.

Foods that are free from contamination at the time they leave foreign shores sometimes become contaminated en route and must be detained. This emphasizes the importance of insisting upon proper storage conditions in vessels, railroad cars, or other conveyances. Many detentions have been made of shipments of foods that may have become contaminated, insect infested, moldy, or otherwise illegal during the journey from the country of origin. While the foreign exporter may be wholly blameless, the law requires action against illegal merchandise no matter where it may have become illegal. Foreign exporters should pack their products so as to protect them against contamination en route, and should urge transportation agencies to protect the merchandise by maintaining sanitary conditions and segregating food from other cargo which might contaminate it. For example, vessels transporting foods may also carry ore concentrates and poisonous insecticides. Improper cargo handling or disasters at sea have resulted in shipments becoming seriously contaminated, with detentions required.

Where import shipments become contaminated after Customs entry and landing (for example, in truck accidents, warehouse and pier explosions or fires, lighter or barge sinkings, etc.) legal actions are not taken under import provisions of the law (801). Action in such cases is by seizure proceedings in a Federal District Court, as in cases involving domestic interstate shipments (304).

Tolerances For Filth

Many inquiries are received by the Food and Drug Administration as to permitted variations from absolute cleanliness or soundness in foods. The act does not authorize "tolerances" for filth or decomposition in foods. It states that a food is adulterated if it consists *in whole or in part* of a filthy, putrid, or decomposed substance. It is obvious that tolerances cannot be recognized, from the additional fact that the mere production of a food under insanitary conditions which may contaminate it with unclean foreign matter renders such food adulterated under the law.

This does not mean that a food is necessarily condemned because of the presence of foreign matter in amounts below the irreducible minimum after all precautions humanly possible have been taken to prevent contamination. In some instances the Food and Drug Administration has informally advised importers of the basis upon which actions are taken against foods which may have been subject to attack by insect pests or subjected to deterioration due to climatic conditions. As commercial practices improve or an insect infestation is brought under control, the basis of action may be lowered. This should not be a hardship on those who prepare the foods in foreign countries, because whatever may be the basis upon which actions are taken at the United States ports on filth and decomposition, it represents only what the careful producer or manufacturer can meet.

FOOD STANDARDS

Section 401 of the Food, Drug, and Cosmetic Act provides:

> Whenever in the judgment of the Secretary such action will promote honesty and fair dealing in the interest of consumers, he shall promulgate regulations fixing and establishing for any food, under its common or usual name so far as practicable, a reasonable definition and standard of identity, a reasonable standard of quality, and/or reasonable standards of fill of containers. However, no definition and standard of identity or standard of quality shall be established for fresh or dried fruits, fresh or dried vegetables, or butter, except that definitions and standards of identity may be established for avocados, cantaloupes, citrus fruits, and melons.

These are standards of identity (to establish or define what a given food product is), of quality (these are minimum standards only and establish specifications for quality requirements), and of fill of container (how full the container must be). Standards are based on the assumption that the food is properly prepared from clean, sound materials. Standards do not usually relate to such factors as deleterious impurities, filth, and decomposition. There are exceptions. For example, the standards for whole egg and yolk products and for egg white products require that these products be pasteurized or otherwise treated to destroy all viable Salmonella micro-organisms. A food which is represented as or purports to be a food for which a standard of identity has been promulgated must comply with the specifications of the standard in every respect.

The standards of quality established under the Food, Drug, and Cosmetic Act must not be confused with "standards for grades" that are published by the United States Department of Agriculture for agricultural products and the United States Department of the Interior for fishery products. Under the Food, Drug, and Cosmetic Act, where a standard of quality has been established, it is a minimum standard only. If a food for which a standard of quality or fill of container has been promulgated falls below such standard, it must bear specified label statements showing it to be substandard in quality or in fill of container; for example, "Below Standard in Quality, Good Food-Not High Grade," in a prescribed size and style of type.

The United States Department of Agriculture grades which have been established are usually designated "Grade A" or "Fancy," "Grade B" or "Choice," or "Grade C" or "Standard." The United States Department of the Interior grades which have been established are usually designated "Grade A," "Grade B," or "Grade C." These grade designations are not required by the Food, Drug, and Cosmetic Act to be stated on the labels, but if they are stated, the product must comply with the specifications for the declared grade.

The standards of FDA govern labeling and composition and should be consulted for detailed specifications. As standards are promulgated they are published in the *Federal Register* of the United States, and are later compiled in the annual edition of the *Code of Federal Regulations, Title 21*. Copies of individual standards may be obtained from the Food and Drug Administration.

Proposed standards offered by the food industry, the Government, or some interested person are formally published in the *Federal Register* in order to get comments and suggestions from all interested parties, including consumers.

After evaluation of the comments and other pertinent facts involved, an order is published which adopts, modifies, or rejects the proposal.

An order or a "rule" may be stayed upon the basis of an objection made by an adversely affected party who requests a public hearing, and in addition, there are provisions in the law for carrying an appeal to a Federal Circuit Court of Appeals.

SPICES, SPICE SEEDS, AND HERBS

This group represents food materials that are subject to the depredations of various animal and insect pests from which they must be protected. They may also become moldy or otherwise decomposed unless properly prepared and stored. In any discussion of methods of preparing and storing foods intended for human consumption, emphasis must be placed on the principle of "clean" food, not "cleaned" food. This is particularly true with spices. One of the most serious consequences of failure to protect spices is contamination with excreta from rats, mice, birds, chickens, or other animals. Imported spices have been found to contain excreta not only of these animals, but of bats, goats, and camels. Insects, larvae, weevils, moths, mites, beetles, flies, etc., and their excreta constitute another problem.

Emphasis should be placed on harvesting, storing, handling, packing, and shipping under conditions which will *prevent* such contamination. Besides shortening the time of exposure in the fields, or in drying or curing spaces which are often in the open, all the necessary preventive measures should be taken to keep animals from walking over or having access to the food material. Separate enclosures may be necessary; places under trees or other perches where birds might roost should be avoided. Barns, sheds, cribs, warehouses, and other storage spaces should be made rodentproof. Experience in the United States has indicated that only by such measures as metal flashing around baseboards, use of concrete floors and foundations, screening of openings and windows, elimination of false ceilings or spaces between inner and outer walls, and of rat and mice harborages of all sorts inside and outside of buildings, can rats and mice be effectively kept away from these products. Where it is not feasible to rodentproof the entire building, for example, a barn on the farm, it might be possible to rodentproof a section or room where the foodstuff is being held.

The same basic principle of prevention of contamination applies in the case of insects. Gauze netting spread over food drying in the open may be necessary to keep insects away. Screening of windows and doors will help to keep insects out of storage or packing places. Careful cleaning and fumigation of premises and equipment before a new crop is put into a storage space may save it from contamination by insects that are left over and have been multiplying unmolested since the old crop was removed. The use of infested secondhand bags is another common source of trouble.

While insecticides and fumigants have their function (for example, in preparing a storage space for the reception of spices or other foods, and in preventing the development of infestation in a lot), a product which is already infested is not made acceptable for food by fumigation because the insects are no less objectionable just because they may have been killed by the fumigation.

Most insecticides and fumigants are poisonous or deleterious substances, and if they contaminate food, the food becomes adulterated and subject to action under the Act. While most of the fumigants are volatile, they may, nevertheless, result in contamination of the food with deleterious residues or adversely affect nutritive values. (A few legal tolerances for such residues have been issued.)

In some cases spices may be used for drug purposes and they then become subject to the drug provisions of the Act discussed in Part II. Those spices or spice oils which are listed in the *United States Pharmacopeia* or the *National Formulary* are subject to the standards set forth in these compendia when used for drug purposes. Spice products should be sold under their correct names; for example, in the United States the spice known to consumers as sage is *Salvia officinalis* L. Other related sages should be labeled to show they are not this variety. Spice products, when offered for importation, should be reasonably free from foreign matter, such as pebbles, dirt, stems, wood chaff, or other extraneous substances peculiar to each type of product.

As an advisory guide as to IDENTITY of food spice products, the Food and Drug Administration uses the following definitions:

SPICES. Aromatic vegetable substances used for the seasoning of food. They are true to name, and from them no portion of any volatile oil or other flavoring principle has been removed.

ALLSPICE, PIMENTO. The dried, nearly ripe fruit of *Pimento officinalis Lindl.*

ANISE, ANISEED. The dried fruit of *Pimpinella anisum* L.

BAY LEAVES. The dried leaves of *Laurus nobilis* L.

CAPERS. The flower buds of *Capparis spinosa* L.

CARAWAY, CARAWAY SEED. The dried fruit of *Carum carvi* L.

CARDAMON. The dried, nearly ripe fruit of *Elettaria cardamomum* Maton.

CARDAMON SEED. The dried seed of cardamom.

CINNAMON. The dried bark of cultivated varieties of *Cinnamomum zeylanicum* Nees or of *C. cassia* (L.) Blume, from which the outer layers may or may not have been removed.

CEYLON CINNAMON. The dried inner bark of cultivated varieties of *Cinnamomum zeylanicum* Nees.

SAIGON CINNAMON, CASSIA. The dried bark of cultivated varieties of *Cinnamomum cassia* (L.) Blume.

CLOVES. The dried flower buds of *Caryophyllus aromaticus* L.

CORIANDER SEED. The dried fruit of *Coriandrum sativum* L.

CUMIN SEED. The dried fruit of *Cuminum cyminum* L.

GINGER. The washed and dried, or decorticated and dried, rhizome of *Zingiber officinale* Roscoe.

MACE. The dried arillus of *Myristica fragrans* Houtt.

MACASSAR MACE, PAPUA MACE. The dried arillus of *Myristica argentea* Warb.

MARJORAM, LEAF MARJORAM. The dried leaves, with or without a small proportion of the flowering tops, of *Marjorana hortensis* Moench.

NUTMEG. The dried seed of *Myristica fragrans* Houtt, deprived of its testa, with or without a thin coating of lime (Ca O).

MACASSAR NUTMEG, PAPUA NUTMEG, MALE NUTMEG, LONG NUTMEG. The dried seed of *Myristica argentea* Warb, deprived of its testa.

PAPRIKA. The dried, ripe fruit of *Capsicum annuum* L.

BLACK PEPPER. The dried, immature berry of *Piper nigrum* L.

WHITE PEPPER. The dried mature berry of *Piper nigrum* L. from which the outer coating or the outer and inner coatings have been removed.

SAFFRON. The dried stigma of *Crocus sativus* L.

SAGE. The dried leaf of *Salvia officinalis* L.

TARRAGON. The dried leaves and flowering tops of *Artemisia dracunculus* L.

THYME. The dried leaves and flowering tops of *Thymus vulgaris* L.

CANNED FRUITS AND VEGETABLES

Canned Fruits and Fruit Juices

Standards of identity, quality, and fill of container have been promulgated for a number of canned fruits and fruit juices. The specific standards should be consulted by anyone intending to ship canned fruit to the United States.

Labels on canned fruits and fruit juices which meet the minimum quality standards, and canned fruits and fruit juices for which no standards of quality have been promulgated, need not make reference to quality, but if they do, the product must correspond to the usual understanding of the labeled grade. Particular care must be taken to use the terms "Fancy" or "Grade A" only on those products meeting the specifications established for such grades by the U.S. Department of Agriculture.

Fill-of-container standards have been promulgated for only a few specified canned fruits and fruit juices, but in packing any other canned fruit the container must be well filled with fruit and with only enough packing medium added to fill the interstices, otherwise the container may be deceptive and the product prohibited by the act. In judging the finished product, due allowance is made for natural shrinkage in processing.

Canned fruits and fruit juices for which identity and quality standards have not yet been promulgated are sometimes imported. Fruit used for canning or juice should be mature and sound, that is, free from insect infestation, moldiness, or other forms of decomposition.

Olives

Pitted and stuffed olives containing more than an unavoidable minimum of pits or pit fragments are regarded as in violation of the Food and Drug Act. While it may not be possible to completely eliminate this problem dealers have been put on notice that they must take steps to reduce it to the extent that is reasonably feasible. In any case, if more than 1 percent of the olives contain pits or fragments the shipment is detained.

Canned Vegetables

Canned vegetable products must be prepared from sound, wholesome raw materials free from decomposition. It has been necessary on occasions to deny entry of canned pimentos and other vegetable products because they have been prepared from sour, fermented raw materials. The definitions and standards of identity which have been promulgated under the Act for a wide variety of canned vegetables provide that "the food is sealed in a container and so processed by heat as to prevent spoilage." The importance of adequate heat processing of canned vegetables, particularly the low-acid types, is emphasized by the danger that spoilage may be caused by *Clostridium botulinum,* the organism responsible for a highly fatal type of food poisoning. It has sometimes been necessary to detain or deny entry to shipments of canned vegetables, canned mushrooms, canned pimentos, and other canned food products because of spoilage resulting from underprocessing or occasionally from the use of defective containers.

Cans of food which have become swells or otherwise abnormal should be destroyed, or turned in to the nearest federal FDA office.

Standards of quality have been promulgated for many vegetables.

If a fill-of-container standard has not been promulgated for a canned vegetable, the container must nevertheless be well filled with the vegetable, with only enough packing medium to fill the interstices. In the case of canned tomatoes, no excess water is needed or permitted by the fill-of-container standard.

Tomato Products

Shippers of tomato products (canned tomatoes, tomato juice, paste, puree, and catsup) should consult the standards of identity for these items. Attention is called to the salt-free tomato solids requirements for puree and paste, and to the fact that neither artificial color nor preservatives are permitted in any of these products. Tomato juice is unconcentrated; tomato puree must contain not less than 8.37 percent and tomato paste not less than 25 percent salt-free tomato solids.

These tomato products are occasionally contaminated with rot because of failure to remove decayed tomatoes from the raw material entering the cannery. Flies and worms are also filth contaminants of tomato products. The preparation of a clean tomato product requires proper washing, sorting, and trimming of the tomatoes and frequent cleaning of the cannery equipment, such as tables, utensils, vats, and pipelines.

In judging whether tomato products have been properly prepared to eliminate rot and decay, the Food and Drug Administration uses the Howard mold-count test, and refuses admission to import shipments and takes action against domestic shipments if mold filaments are present in more than 40 percent of the microscopic fields in the case of puree, paste, more than 30 percent in the case of catsup, or sauce, or more than 20 percent in the case of tomato juice. Methods of testing tomato products are given in the *Methods of Analysis of the Association of Official Analytical Chemists.*

DRIED FRUITS AND VEGETABLES

Much, if not all, that has been said about prevention of contamination of spices is applicable to other perishable foods such as dried fruits and vegetables which are subject to attack by insects, other animals, or to deterioration resulting in moldiness or other forms of decomposition.

Dried Figs and Dates

Dried figs, both domestic and foreign, are subject to insect infestation during their growth, and/or when stored under unsuitable conditions. Figs may also become moldy if not properly stored and handled. The industry has made substantial progress in recent years in eliminating conditions which result in contamination or deterioration of figs, but it is still necessary to refuse entry to some dried figs and fig paste because of such contamination. Figs are classified as objectionable if they show evidence of insect larva, either dead or alive, insect webbing, insect excreta, or other insect filth. Figs are also classified as objectionable if they show evidence of rodent contamination, or of mold, sourness, or fermentation.

Fig paste made from lots of figs containing such objectionable figs is also classified as objectionable, and thus not entitled to entry.

Dried dates, as with dried figs, are refused entry if insect infested, if they contain other forms of filth, or are moldy or decomposed. Care should be taken both during production and during storage to avoid contamination or deterioration of the dried dates. The presence of unpitted dates, or dates containing broken pieces of pits, in shipments of "pitted dates" is a cause for refusing shipments.

Dried mushrooms

Only edible species should be offered for import. The most common bar to entry, however, is insect infestation, usually by flies or maggots. This is especially true in the case of dried wild mushrooms, which grow in the open, unprotected by any kind of enclosure. Dried wild mushrooms should be handled by people who know how to sort out insect-infested mushrooms and those not clearly identifiable as edible species. If insect infestation is so heavy in a particular growing area that it is impractical to sort out the insect-infested mushrooms, then the mushrooms from that area should not be offered for entry. The mushrooms should be adequately protected during drying and storage to prevent their contamination with storage insects, rodent and bird filth or other objectionable material. Canned mushrooms should be essentially free of insect infestation. Since the canned product is prepared from domesticated varieties grown under enclosure the careful producer can readily prevent access by insects.

FRESH FRUITS

Apples and other fruits bearing excessive residues from insecticide sprays or dusts are classed as adulterated under the Federal law. See paragraph entitled "Pesticidal Residues on Raw Agricultural Products."

Pineapples showing or likely to show the internal condition known as "brown heart," or "black heart," should not be offered for entry into the United States.

Blueberries and huckleberries sometimes contain small larvae which render them unfit for food. Fruit from infested areas should be avoided. Fresh blueberries should be held and transported under conditions which will prevent deterioration and decomposition evidenced by mold or other indications of unfitness.

PESTICIDAL RESIDUES ON RAW AGRICULTURAL PRODUCTS

"Raw agricultural product" means any food in its raw or natural state, including all unprocessed fruits, vegetables, and grains. Products of this kind containing pesticide residues are in violation of the Federal Food, Drug, and Cosmetic Act unless (1) the pesticide chemical has been exempted from the requirement of a tolerance, or (2) a tolerance has been established for the particular pesticide on the specific food and the residue does not exceed the established tolerance.

Tolerances for pesticidal residues on many raw agricultrual commodities have been established under the law. Tolerances are established, revoked, or changed, as the facts warrant such action. Firms considering offering for entry into the United States raw agricultural commodities which may contain pesticidal residues should write to the Food and Drug Administration, U.S. Department of Health, Education, and Welfare, Rockville, Maryland 20852, for current information concerning the enforcement of tolerances for residues on raw agricultural products.

FRUIT JAMS (PRESERVES), JELLIES, FRUIT BUTTERS, MARMALADES

Standards of identity have been promulgated for jams, jellies, and fruit butters, including those artificially sweetened. The standards for jams and jellies require that there be in the batch not less than 45 parts by weight of fruit (or fruit juice in the case of jelly) to each 55 parts by weight of sugar or other optional sweetening ingredient. However, for standardized artifically sweetened products the fruit ingredient must be not less than 55 percent by weight of the finished food product. Only sufficient pectin may be added to jams and jellies to compensate for deficiency, if any, of the natural pectin content of the particular fruit. The standards also require a certain degree of concentration. In the case of jellies the finished product must be concentrated to not less than 65 percent soluble solids. In the case of jams (preserves) the finished jam should have not less than 65 percent soluble solids if made from certain specified fruits. With other designated fruits the batch must be concentrated to 68 percent soluble solids.

Fruit butters are defined in the standards of identity as the smooth, semi-solid foods, made from not less than five parts by weight of fruit ingredient to each two parts of sweetening ingredient.

Jams, jellies, and similar fruit products should, of course, be prepared only from sound fruit. Decayed or decomposed fruits and insect-contaminated fruits should be sorted out and discarded.

FISHERY PRODUCTS

Fish and shellfish are imported in the fresh, frozen, canned, salted, dried, or smoked conditions. The raw materials are by nature extremely perishable and must be handled rapidly under adequate refrigeration if decomposition is to be avoided. The conditions of handling are also likely to result in contamination of the raw materials unless particular safeguards are imposed. Decomposition problems are not peculiar to any one type or class of fish products but may occur in any or all types. In some instances examination of imported seafood products has diclosed evidence of the packing of decomposed raw materials. In occasional cases decomposition is the result of active spoilage caused by insufficient processing or preservation.

Sometimes preservatives have been used to prevent or retard spoilage in fish. Any preservative used must be harmless and must be declared on the label.

Chemical contamination of lakes, rivers and oceans has been found to concentrate in certain species of fish. Excessive residues of pesticides (DDT), mercury and other heavy metals are prohibited. Tuna and swordfish, particularly, are banned from importation or sale if mercury residues exceed 0.5 part per million.

Names for Seafoods

To prevent substitution of one kind of seafood for another, and consequent deception of the consumer, it is essential that labels bear names which accurately identify the products designated. Labels of seafoods, like the labels for other foods, must bear the common or usual name of the food, if there is one. Words like "fish," "shellfish," or "mollusc," are not sufficient; the name of the specific seafood must be used. Many fish, crustaceans, and molluscs have well established common or usual names throughout the United States (for example, "pollock," "cod," "shrimp," and "oyster"). These may not be replaced with other names, even though the other names may be used in some areas or countries. Neither may they be replaced with coined names, even though the coined name may be considered more attractive or to have greater sales appeal.

A more difficult problem is deciding what constitutes the proper designation for a seafood which has not previously been marketed in the United States, and thus which has not acquired an established common or usual name in this country. In selecting an appropriate name for such a product, full consideration must be given to its proper biological classification, and to avoid a designation which duplicates or may be confused with the common or usual name in this country of some other species.

Labels on frozen fishery products for which no standards of quality have been promulgated need not make reference to quality, but if they do, the product must correspond to the usual understanding of the labeled grade. Particular care must be taken not to use the term "Grade A" on products that do not meet the established understanding of these terms in the United States.

Canned Fish

Failure to declare the presence of added salt or the kinds of oil used as the packing medium in canned fish has resulted in the detention of fish products. If permitted artificial colors or chemical preservatives are used, their presence must be conspicuously declared in the labeling. Artificial coloring is not permitted if it conceals damage or inferiority or if it makes the product appear better or of greater value than it is.

The packing of canned fish and fish products with excessive amounts of packing medium has resulted in many detentions. The can, in canned food products, serves not only as a container but also as an index of the quantity of food therein. Where the fish are in a packing medium such as anchovies in oil, the container should be as full as possible of fish with the minimum amount of oil. The fact that the oil may be equal in value or even more expensive than the fish does not affect this principle. Canned lobster paste and similar products have been encountered which were deceptively packaged because of excessive headspace, i.e., excessive space between the lid of the can and the surface of the food in the can.

Anchovies

Products represented as anchovies should consist of fish of the family *Engraulidae*. Other small fish such as small herring and herringlike fish which may superficially resemble anchovies, cannot properly be labeled as anchovies. The product should be prepared from sound raw material and the salting or curing should be conducted in such a manner that spoilage does not occur.

Sardines

The term "sardines" is permitted in the labeling of the canned products prepared from small-size clupeoid fish. The sea herring *(Clupea harengus)* the European pilchards *(Sardina pilchardus* or *Clupea pilchardus)*, and the brisling or sprat *(Clupea sprattus)* are commonly packed in oil in small-size cans and labeled as sardines. The terms "brisling sardines" and "sild sardines" are premissible in the labeling of canned small brisling and herring, respectively. Large-size herring cannot be labeled sardines. These canned products must be free from all forms of decomposition such as "feedy," "belly-blown" fish and must be adequately processed to prevent active spoilage by micro-organisms. Fish are called "feedy fish" when their stomachs are filled with feed at the time the fish are taken from the water. Such fish deteriorate rapidly until the viscera and thin belly wall disintegrate producing a characteristic ragged appearance called "belly-blown."

Tuna

The standard of identity defines the species of fish that may be canned under the name tuna.

The standard provides for various styles of pack, including solid pack, chunk or chunk style, flakes, and grated tuna. Provision is also made for various types of packing media, certain specified seasonings and flavorings, and color designations.

The meat canned from the fish *Sarda chilensis,* commonly known as the bonito or bonita may not be labeled as tuna since it is not a true tuna but must be labeled as bonito or bonita. The meat of *Seriola dorsalis*, commonly known as "yellowtail" must be labeled as yellowtail and may not be designated as tuna.

Fresh and Frozen Fish Fillets

The products are highly perishable and require extraordinary care if decomposition is to be avoided. The manufacturer must exercise extreme care in the selection of raw materials to remove any unfit, decomposed material and then to maintain the product in a sound, wholesome condition, to avoid the denial or entry to such importations.

An important problem has arisen in connection with the importation of certain species, such as whitefish, tullibees, lake herring, chubs, and ciscoes, which are subject to infestation with a repulsive form of parasite. This condition is in the form of cysts containing the parasite and puslike material in the flesh of the fish. The presence of such cysts renders the fish filthy and as such they may not be imported into the United States.

Shellfish

Because of raw shellfish, such as oysters, clams, and mussels may transmit intestinal diseases such as typhoid fever, it is extremely important that they be grown in unpolluted waters and produced, handled, and distributed under sanitary conditions. Shellfish must conform to the general requirements of the Food, Drug, and Cosmetic Act, but, in the importation of shellfish into the United States, consideration must be given also to the requirements of the States to which the shellfish are destined, if they are to be accepted under the respective State laws.

Standards of identity have been promulgated for canned oysters, raw oysters, Pacific oysters, and frozen raw breaded shrimp. Additionally, standards of fill of container have been promulgated for canned wet packed shrimp in nontransparent containers and canned oysters.

Clams

Certain shellfish, particularly clams, may contain a toxic substance *Gonyaulax catenella*, derived from a plankton organism upon which the shellfish feed. Such toxic shellfish may cause illness or even death. The sources of supply of shellfish intended for shipment to the United States should be periodically tested for the presence of gonyaulax.

Caviar and Fish Roe

The name "caviar" unqualified may be applied only to the eggs of the sturgeon prepared by a special process. Fish roe prepared from the eggs of other varieties of fish, prepared by the special process for caviar, must be labeled to show the name of the fish from which they are prepared, for example, "whitefish caviar." If the product contains an artificial color, it must be of an approved color and its presence must be stated on the label conspicuously. No artifical color should be used which makes the product appear to be better or of greater value than it is. If a chemical preservative is employed, it must be one the harmlessness of which have been established, and it must be declared on the label.

Rock Lobster, Spiny Lobster, Sea Crayfish

The sea crayfish, *Palinurus vulgaris*, is frequently imported into the United States in the form of frozen tails, frozen cooked meat, or canned meat. By long usage, the terms "Rock Lobster" and "Spiny Lobster" have been established as common or usual names for these products. No objection has been offered to either of these terms, providing the modifying words "rock" or "spiny" are used in direct connection with the word "lobster" in type of equal size and prominence.

In examination of imports, decomposition has sometimes been detected in all three forms of the product. In the canned product, decomposition resulted from the packing of decomposed raw material and also from active bacterial spoilage. In the frozen cooked product, detentions have been necessary also because of the presence of micro-organisms indicative of pollution with human or animal filth, as well as of decomposition.

MEAT AND POULTRY

Meat and Meat Food Products

Meat or meat products derived from cattle, sheep, swine, goats, and horses are subject to the provisions of the Wholesome Meat Act enforced by the Consumer and Marketing Service of the U.S. Department of Agriculture. Foreign meat products must originate in countries whose meat inspection programs have been approved. Each shipment must be properly certified by the foreign country and upon inspection by the Federal meat inspectors found to be completely sound, wholesome, and fit for human food before entry into the United States. Requests for inspection should be made to the C & MS Technical Services. The imported product after admission into the United States becomes a domestic article subject not only to the Federal Meat Inspection Act but also to the Federal Food, Drug, and Cosmetic Act to the extent the provisions of the Meat Inspection Act do not apply.

Poultry and Poultry Products

Poultry and poultry products offered for importation are subject to the Wholesome Poultry Act which is enforced by the U.S. Department of Agriculture, to which inquiries concerning such products should be addressed. The term "poultry" means any live or slaughtered domesticated bird (chickens, turkeys, ducks, geese, or guineas), and the term "poultry product" means any poultry which has been slaughtered for human food, from which the blood, feathers, feet, head, and viscera have been removed in accordance with rules and regulations promulgated by the Secretary of Agriculture, or any edible part of poultry, or, unless exempted by the Secretary, any human food product consisting of any edible part of poultry, separately or in combination with other ingredients.

After importation into the United States, poultry and poultry products are also subject to the Federal Food, Drug, and Cosmetic Act to the extent to which the provisions of the Poultry Products Inspection Act do not apply.

Gelatin

Gelatin is not held to be a meat food product amendable to the Federal Imported Meat Act. The provisions of the Food, Drug, and Cosmetic Act require it be prepared from clean, sound wholesome, raw materials, handled under sanitary conditions, containing no glue or other gelatin-like material with a low gelatinous power or having a disagreeable odor or taste. It should be so prepared and marketed as to be free from spoilage, filth, or putridity. It should be free from such preservatives, metals, and salts of metals as may render its use injurious to health.

MAYONNAISE, FRENCH DRESSING, AND SALAD

Standards of identity have been established for mayonnaise, mayonnaise dressing, french dressing, and salad dressing. Mineral oil is not a permitted ingredient in any of these foods.

FOODS FOR SPECIAL DIETARY USES

Section 403 (j) of the Food, Drug, and Cosmetic Act classes a food as misbranded "If it purports to be or is represented for special dietary uses, unless its label bears such information concerning its vitamin, mineral, and other dietary properties as the Secretary determines to be, and by regulations prescribes as, necessary in order fully to inform purchasers as to its value for such uses."

Regulations referred to in section 403 (j) were promulgated in 1941. At the same time in general regulation under the act (Regulation 1.11) was issued interpreting the term "special dietary uses" as used in the statute. This general regulation is as follows:

> (a) The term "special dietary uses," as applied to food for man, means particular (as distinguished from general) uses of food, as follows: (1) Uses for supplying particular dietary needs which exist by reason of a physical, physiological, pathological or other condition, including but not limited to the conditions of disease, convalescence, pregnancy, lactation, allergic hypersensitivity to food, underweight, and overweight; (2) Uses for supplying particular dietary needs which exist by reason of age, including but not limited to the ages of infancy and childhood; (3) Uses for supplementing or fortifying the ordinary or usual diet with any vitamin, mineral, or other dietary property. Any such particular use of a food is a special dietary use, regardless of whether such food also purports to be or is represented for general use. (b) No provision of any regulation under section 403 (j) of the act shall be construed as exempting any food from any other provision of the act or regulations thereunder, including sections 403 (a) and (g) and, when applicable, the provisions of Chapter V.

The regulations under section 403 (j) prescribe label statements of the dietary properties upon which the special dietary use of the food is based. They provide that labels of foods represented as for special dietary use by reason of their vitamin or mineral content shall state the proportion of the minimum daily requirement for each such vitamin or mineral supplied by the food when consumed in a specified quantity in 1 day. The regulations specify the minimum daily nutritional requirements of certain vitamins and minerals. The regulations also prescribe label statements relating to infant food, label statements relating to food used in control of body weight or in dietary management with respect to disease, label statements relating to nonnutritive constituents, label statements relating to hypoallergenic food, and to foods intended for use in low-sodium (salt restricted) diets.

Importers and foreign shippers should consult the detailed regulations under section 403 (j) before importing foods represented by labeling or otherwise as special dietary foods.

When special dietary foods are labeled with health claims, they are subject to the drug provisions of the Act.

FOOD ADDITIVES

"Food Additives" are substances which may by their intended uses become components of food, either directly or indirectly, or which may otherwise affect the characteristics of the food. The term specifically includes any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding the food, and any source of radiation intended for any such use (409).

But the law excludes from the definition of a "food additive"—

1. Substances generally recognized as safe by qualified experts;
2. Substances used in accordance with previous approval ("prior sanction") under either the Federal Food, Drug, and Cosmetic Act, the Poultry Products Inspection Act (21 USC 451) or the Meat Inspection Act;
3. Pesticide chemicals in or on raw agricultural products;
4. A color additive;
5. A new animal drug; (but these (3, 4 and 5) are subject to similar safety requirements of other sections of the law).

Manufacturers or importers not certain whether the chemicals or other ingredients used in their foods are subject to the safety clearance requirements of the Food Additives Amendment may seek an opinion from the Food and Drug Administration. If safety clearance is necessary, this may mean that studies including animal feeding tests will have to be carried out in accordance with recognized scientific procedures, and the results submitted to the Food and Drug Administration for evaluation. The law provides that no additive may be found safe if it produces cancer on ingestion in test animals, or if it is shown by other appropriate tests to be a cancer-producing agent, except that such ingredient may be used in feeds if it causes no harm to the animal and provided there are no residues of the ingredient in the meat or other products reaching the consumer. This provision is primarily applicable to veterinary drugs added to animal feed.

If the Food and Drug Administration concludes from the evidence submitted to it that the additive will be safe, a regulation permitting its use will be issued. This regulation may limit the amount of the substance which may be present in or on the foods, the foods in which it is permitted, the manner of use, and specify any special labeling required.

A substance cleared under the Food Additive Regulations is still subject to all the general requirements of the Food, Drug, and Cosmetic Act with regard to its use in other foods and with respect to label declarations.

COLOR ADDITIVES

The Federal Food, Drug, and Cosmetic Act provides that foods, drugs, and cosmetics are adulterated if they contain color additives which have not been proved safe to the satisfaction of the Food and Drug Administration for the particular use. A color additive is a dye, pigment, or other substance, whether synthetic or derived from a vegetable, animal, mineral, or other source, which imparts a color when added or applied to a food, drug, cosmetic, or the human body.

Regulations are issued listing permitted color additives and the conditions under which they may be safely used, including the amounts that may be used when limitations are necessary. Separate lists are provided for color additives for use in or on food, drugs, and cosmetics, though some colors may appear on more than one list.

Testing and certification by the Food and Drug Administration of each batch of color is required before use in foods, drugs, or cosmetics, unless certification of the color additive is specifically exempted by regulation.

The manufacturer who wants to use color additives in foods, drugs, or cosmetics should check the regulations to ascertain which colors have been listed for various uses. Before using the colors he should read the labels, which are required to contain sufficient information to assure their safe use, and observance of any limitations placed on such use, such as "for food use only," directions for use where tolerances are imposed, or warnings against use, such as "Do not use in products used in the area of the eye."

Manufacturers of certifiable colors may address requests for certification of batches of such colors to the Food and Drug Administration, Washington, D.C., 20204. Certification is not limited to colors made by United States manufacturers. Requests will be received from foreign manufacturers if signed by both such manufacturers and their agents residing in the United States. Certification of a color by an official agency of a foreign country cannot under the provisions of the law, be accepted as a substitute for certification by the Food and Drug Administration.

For copies of regulations governing the listing, certification, and use of colors in foods, drugs, and cosmetics shipped in interstate commerce or offered for entry into the United States, or answers to questions concerning them, write to the Food and Drug Administration, Washington, D.C., 20204.

SUGGESTIONS TO FOREIGN EXPORTERS AND UNITED STATES IMPORTERS TO EXPEDITE ENTRIES

Be sure packaged foods, drugs, and cosmetics are labeled. Unlabled goods must necessarily be detained because of lack of the mandatory label information. This causes delays that might not otherwise occur.

Do not import products known to be illegal on the theory that they can be brought into compliance with the law upon arrival. Conditional releases for that purpose are discretionary under the Food, Drug, and Cosmetic Act and if the privilege is granted, delays and added expense to importers inevitably occur before final release or denial of release. Correct at the source obviously objectionable conditions responsible for detentions, such as infestation of crude drugs, foods, etc., with insects and other vermin.

Make U.S. Customs entries promptly upon arrival of shipments at the port of entry. The Food and Drug Administration cannot ordinarly act upon an importation until entry is actually filed and the Customs Bureau has notified the Administration's local office. Entry documents should be "flagged" for the attention of the FDA representative at the appropriate office.

In carrying on business transactions with the importing trade of the United States, foreign shippers, as well as the importing purchasers, should bear in mind that they have a definite obligation to comply fully with United States laws affecting these commodities. Sustained effort should be made to bring about fundamental correction of any existing conditions which adversely affect purity, strength, or quality of such articles.

Such corrective measures might well be undertaken by individual producers and associations of producers, and possibly by foreign Government agencies in the countries of production. By such procedures, eradication of causes of deterioration and contamination in a number of commodities has already been successfully accomplished in various parts of the world, with a resulting great reduction in number of adverse actions by the Food and Drug Administration when shipments were offered for entry into the United States. Moreover, individuals and associations and various foreign Government agencies have, in a number of instances, instituted systems for sampling and examination of specific lots intended for shipment to the United States for the purpose of predetermining whether specific lots so intended meet the requirements of the United States Laws.

GRAS SUBSTANCES

There are a number of substances that are classified by U.S. Food and Drug Administration as "generally recognized as safe," or GRAS. That group of substances is exempted from the requirements of proving that they are safe. Those materials are classified as GRAS on the basis of prior scientific evaluation or from experience based on long time usage in food. Lists of GRAS substances covering some 600 materials are periodically revised and issued by U.S. F&DA.

Typical GRAS substances include common salt (sodium chloride), common sugar (sucrose), ascorbic acid (vitamin C), fruit and beverage acids like citric, malic and phosphoric, caramel, benzoic acid and sodium benzoate, emulsifiers such as fatty acid monoglycerides and diglycerides, potassium iodide, glycerol, numerous flavoring materials, and many others.

Criteria for eligibility for classification of substances in the GRAS list is included in Section 121.3 of the U.S. Food, Drug, and Cosmetic Act.

LOW-ACID CANNED FOODS GOOD MANUFACTURING PRACTICE REGULATIONS

The U.S. Food and Drug Administration has been engaged in a program to improve its surveillance over the food supply. There are several elements of this program: (a) the publication of regulations which inform the industry just what is expected of them by FDA, (b) the addition of 700 new inspectors, (c) the training of inspectors in food technology, and (d) the adoption of improved inspectional techniques.

The first pertinent regulation, one sometimes overlooked, is the so-called "Unbrella Regulation," Part 128 entitled Human Foods; Current Good Manufacturing Practice (Sanitation) in Manufacture, Processing, Packing or Holding. This regulation is intended to cover in a general way all types of operations in the commercial processing and handling of foods. Subsequent supplementary regulations have been and are being promulgated to cover more specifically the various categories of food manufacturing operations. The first of these was Part 128a – Fish and Seafood Products. The second was Part 128b – Thermally Processed

Low-Acid Foods Packed in Hermetically Sealed Containers. Other GMP regulations have been proposed and still others are being prepared.

Regulation 128b – Thermally Processed Low-Acid Foods Packed in Hermetically Sealed Containers is the most extensive and the most detailed GMP regulation thus far. It delineates equipment and its hook-up, operating procedures required to assure safety of the foods, records to be maintained, and the training required for plant personnel supervising retort operations and container closure operations. The regulation was first proposed to FDA by industry through the National Canners Association in November 1971. It was published as a final order on January 26, 1973.

The legal basis for Regulation 128b and other GMPs is Section 402(a)4 of the U.S. Food, Drug and Cosmetic Act which states: "A food shall be deemed to be adulterated if it has been prepared, packed or held under insanitary conditions whereby it may have become contaminated with filth or whereby it may have been rendered injurious to health".

Microbiological spoilage due to any cause is of course of concern to industry and to FDA, whether or not it has public health significance. The provisions of Regulation 128b are intended to render the food "commercially sterile," that is, free of all viable microorganisms capable of reproducing in the food under normal nonrefrigerated conditions of storage and distribution. The thermal processes required to achieve commercial sterility are also more than adequate to inactivate the spores of *Clostridium botulinum*, the dreaded organism in the canning industry. This organism, widely prevalent in nature, particularly in soils, grows only under anaerobic conditions. While we ingest the organism regularly in fresh foods without any ill effects, when the organism is presented an anaerobic environment in the sealed container, it can multiply and produce its deadly toxin if the pH of the product is higher than 4.6. This is a valid generalization to which there are some exceptions.

Over a period of 40 years there were hundreds of cases of botulism in home canned foods in the United States. During that period there were no reported cases of botulism attributed to the billions of units of commercially processed canned foods. In recent years, however, that excellent track record has been blemished by a few well known cases of botulism. This has caused much concern.

Regulation 128b contains both mandatory provisions and advisory suggestions, all of which are recognized as current good manufacturing practices. Meticulously followed, these practices will greatly improve the safety of low-acid canned foods. In one respect the regulation is unique: it recognizes the importance of people and requires that all retort operations and all closure operations and inspections be performed under the supervision of personnel who have successfully completed a training course conducted by a school approved by the Commissioner of Food and Drugs. These have become known as "Better Process Control Plan" schools.

Food Plant Inspection

Food plant inspection as historically practiced in the United States has been based on the observation of operating conditions on the day of inspection. Many corrective actions were achieved through this approach. This type of inspection undoubtedly will be continued because it is quite applicable to certain segments of the food industry; the inspection of warehouses is a good example.

This type of inspection provides little information on the manner in which the operation is conducted when the inspector is not present at the plant. It also does not tell much about the procedures employed by management to monitor and control their operations on a continuing basis.

To determine whether the plant is doing a good job consistently, it is necessary to audit the production logs, charts, and written quality control records covering a fairly long period of time. On the day of an inspection, for example, observing that adequate times and temperatures are being used in the processing of a food does not always mean that this is the every day procedure. If clear instructions are posted and detailed records exist showing evidence of a properly functioning quality assurance system, then one can be reasonably assured of an acceptable product every day. If the quality control records are not up-to-date or are non-existent, then it is probable that some of the finished product is substandard or even unsafe.

Hazard Analysis and Critical Control Point Inspection (HACCP)

The Hazard Anaylsis and Critical Control Point inspectional approach complements the traditional inspectional methods. It determines which points in the process are critical to the safety and sanitary quality of the product, and how well the firm controls these points. This new FDA inspectional approach is preventative in nature, attempting to bring potential dangers to the attention of management for before-the-fact corrective action. The continued development of this trouble-preventing approach to plant inspections is an important objective in the FDA program. Ultimately, it should assure that the consumer is not exposed to substandard, potentially insanitary or hazardous foods resulting from improper plant practices.

Part 90 – Subparts A and B

Chapter 1 of Title 21 of the Code of Federal Regulations was amended by adding to Part 90 subparts A and B. Subpart A regards definitions and procedures for effecting emergency permit control in food plants where there may be a microbiological threat to health, where the injurious nature cannot be determined adequately after shipment into interstate commerce. Subpart B concerns the emergency permit provisions specifically for thermal processing of low-acid foods packaged in hermetically sealed containers. These regulations will greatly assist FDA in preventing suspect canned low-acid foods from entering interstate commerical channels. Subpart B requires all canners of low-acid foods to register with FDA, listing all their producing plants. Furthermore, the firms must file their scheduled thermal processes; this requirement is expected to enable FDA further to prevent problems of a public health nature. For example, when a spoilage problem is encountered, a computer readout will immediately locate all other plants using similar scheduled processes for the same product; the firms can then be alerted to a potentially hazardous situation.

The vast majority of the food-canning industry earnestly wants to do everything it can to make the industry products completely safe. The establishment of Current Good Manufacturing Regulations is intended to help the industry know what is necessary to achieve that goal.

THE FAIR PACKAGING AND LABELING ACT

FDA Regulations

The federal Fair Packaging and Labeling Act was enacted in 1966, and took effect on July 1, 1967. Under certain conditions, specific extensions to compliance with the regulations of the FPL Act have been granted by the Food and Drug Administration. Otherwise, labels on all food products must comply with that law.

The FDA incorporated the requirements under the Food, Drug, and Cosmetic Act and the Fair Packaging and Labeling Act into a single set of regulations. FDA did note, however, that some specific requirements for the net quantity declaration (such as uniform location, lack of qualification, type size, and dual statement of contents) and the declaration of the quantity of a serving when the number of servings is given, are solely provisions of the Fair Packaging and Labeling Act. This distinction is important, because each law carries different penalties for violations. The other parts of the regulations are provided for by both the FPL and FDC Acts.

The regulations add to the definitions and interpretations of terms appearing in the FDC Act, the following:

"Label" means any display of written, printed, or graphic matter on the immediate container of any consumer commodity, affixed to any consumer commodity, or affixed to any package containing a consumer commodity.

"Package" means any container or wrapping in which a consumer commodity is enclosed for delivery to retail purchasers. Transparent wrappers which do not obscure the required label information appearing on an inner label, and certain shipping or display containers, are excluded from this definition.

"Principal display panel" of a food package means that part of a label that is most likely to be shown or examined under customary conditions of display for retail sale. This panel shall be large enough to accommodate all the mandatory label information, clearly and conspicuously.

"Area of the principal display panel" means the area of the side or surface of the package that bears the principal display panel. The method of measuring this area for rectangular, cylindrical, and irregularly shaped containers is given in the regulations.

The following information is required on the label of food packages:

1. A statement of the identity of the food. This statement of identity must appear on the principal display panel, in bold type, and in lines generally parallel to the base of the package as it is displayed. It shall be stated as the common or usual name of the food, such as "beets" or "peaches." If there is no common name, appropriately descriptive terms or a commonly understood fanciful name may be used. For example, foreign names of exotic foods (e.g., vichyssoise, borsch) or trade names commonly associated with products such as Coca-Cola or 7-Up. When a food is offered in various forms, such as whole, sliced, or chopped, the particular form shall be a prominent written part of the statement of identity, unless depicted by vignette, or when it is visible through the container.

2. A statement of the name and address of the manufacturer, packer, or distributor. This information shall be conspicuously stated, with an appropriate

description of the relationship of the business, such as "packed for" or "distributed by," if the name given is not that of the manufacturer. The name under which the business is conducted is required. In the case of a corporation, the actual corporate name must be given. The name of a particular division of the corporation may also be stated. The place of business shall be the full address–street, city, state, and zip code. If, however, the street address is listed in a current city or telephone directory, this portion of the address may be omitted.

3. A statement of the net quantity of contents. This statement shall appear without any qualifying terms-"Giant Quart," "Jumbo Pound"-which may exaggerate the amount of the food in the package. It shall be placed within the bottom 30 percent area of the principal display panel as a distinct item, separated from any other printed label information and in lines generally parallel to the base of the package. (Display panels less than 5 square inches are exempt from the lower 30 percent requirement; all other requirements apply.) It shall appear in easily legible boldface type, and in type sizes established in relationship to the area of the principal display panel of the package. The regulations specify five minimum type sizes to be used on packages ranging from the smallest (5 square inches or less) to the largest (more than 400 square inches).

The statement shall be in terms of fluid measure–U.S. gallon, quart, pint, and fluid ounce–if the food is liquid. If the food is solid, semisolid, or viscous, or a mixture of solid and liquid, the statement shall be in terms of weight–avoirdupois pound and ounce. In the case of fresh fruits or vegetables, for instance, when sold by dry measure, the statement shall be in terms of U.S. bushel, peck, dry quart or dry pint.

If there is a firmly established custom of declaring the contents of a particular commodity in terms other than those stated above, this custom may be continued. However, at any time that the Commissoner of Food and Drugs determines that this established custom offers an opportunity for consumer confusion, he may designate another appropriate term or terms to be used.

The net contents declaration shall be an accurate statement of the quantity of food contained in the package. It shall not include the weight of any packaging material. The amount of propellant in a food designed for delivery under pressure (instant whipped cream, for example) may be included in the net contents. The regulations spell out the appropriate temperatures at which frozen foods, refrigerated foods, and other foods are to be measured.

A dual declaration of net contents is required for packages containing less than 4 pounds but at least 1 pound, or less than 1 gallon but at least 1 pint. The more prominent declaration shall be in terms of total ounces or total fluid ounces. The second statement shall be placed in parenthesis to set it apart from and avoid confusion with the primary statement. For foods measured by weight, this second statement shall be expressed in terms of pounds and ounces, or pounds and common or decimal fractions of the pound. For liquid measure, this second statement shall be expressed in terms of quarts, pints, and fluid ounces or fractions of the pint or quart (the largest whole unit of measure shall always be given first).

A separate statement of the net contents in terms of the metric system of weights and measures may also appear on the principal display panel. Additional information relating to the net quantity of contents may be given, but it must be truthful, and it may not appear on the principal display panel.

4. A statement of the net contents of a serving. If the label of any food package represents the contents in terms of the number of servings, then this statement shall be accompanied by a description of the size of each serving. The contents of the serving may be stated in units of weight, liquid or dry measure, or in other commonly understood terms of measurement, such as tablespoonfuls or cupfuls.

The contents of a serving must conform to any definition included in a voluntary product standard promulgated by the Department of Commerce.

5. A statement listing ingredients. When required, this statement shall appear on a single panel of the label and shall be legible by virtue of type size, design, etc. It shall list the ingredients by their common name in decreasing order of predominance. In cases where the presence of a single, expensive ingredient is promoted as significant to the value of the food, additional information, such as a declaration of the percent of the expensive ingredient present, will be required.

Under the provisions of the Federal Food, Drug, and Cosmetic Act, the FDA had the authority to issue exemptions to specific regulations on an industrywide basis. The Fair Packaging and Labeling Act also allows exemptions to be granted, but it directs the Agency to consider this technique of dealing with unusual cases on a commodity-by-commodity basis. The Commissioner has, therefore, revoked the regulations which exempted small packages from certain labeling requirements. He has formalized the procedure by which exemption from one or more provisions of the regulations may be requested, and has, by regulation, granted exemptions in four specific cases.

Net Contents

The statement of net contents must show the amount of food in the can. With most products it is the total net contents. In the case of a few products like green olives in brine, the brine is not used for food, only the amount of the solid material should be stated. The usual net contents statement for the principal canned foods in the usual containers are given in the "Net Weight List" issued by the Nation Canners Association. However, the canner should always check the net contents of each of his own product.

Labeling

Labels are almost always put on the containers by special machines designed for the purpose. These are adjustable to handle all size cans or jars of the same general shape such as the ordinary cylindrical can or the usual style glass jar. Several types of label paste are available. There have been instances where the paste used on labels caused rusting of the cans. The canner should demand that the paste purchased will not affect either the can or the label. Usually a separate paste is used for picking up the label as the can rolls over it–the "pick-up gum"; and for sealing the over-lapping ends of the label–the "lap paste."

NUTRITIONAL LABELING

As public awareness of the nutritional qualities of foods increases, so increases the demand on food manufacturers for nutritional information on their food products. Recently published FDA Food Labeling Regulations permit, or in some cases require, nutrition labeling of packaged food products. This section enumerates some of the key provisions, summarizes the headings, sequence and contents of the labeling regulations and lists some general precautions and recommendations about adopting and implementing nutrition labeling.

The regulations regarding "Food Label Information Panel", "Nutrition Labeling" and "Cholesterol, Fat and Fatty Acid Labeling" appear in Title 21 of *Code of Federal Regulations* Part 21, paragraphs 1.8d, 1.17 and 1.18 respectively. The regulations tightly control the substance and format of nutrition labeling. Compliance with the regulations is not simple. Individual manufacturers must acquire first-hand knowledge and thorough understanding of both technical and legal aspects of the Regulations before Nutrition Labeling can be safely implemented. The Division of Nutrition, Food and Drug Administration, 200 C Street, Washington, D.C., 20204, can be contacted regarding specific questions or for requesting available materials on compliance procedures, analytical methods, etc.

Key Provisions

1. Labels of all packaged foods must include an "Information Panel" in which mandatory product information such as ingredient itemization and name and address of manufacturer is compiled into a single location on the label, normally the panel to the immediate right of the Principal Display Panel.

2. The Information Panel *must* include Nutrition Information of a) the product formula includes any added nutrients, or if b) any nutritional claim is made for the product. "Nutrition Claim" is broadly interpreted and might include e.g., "high protein", "low calorie", "high vitamin C", "more nutritious", "low cholesterol", or "high in polyunsaturated fat". Products enriched in accordance with FDA Standards of Identity are exempted from mandatory Nutrition Labeling if no nutrition claims are made.

3. Both voluntary and mandatory Nutrition Information must include specified data, must appear in a mandatory format and must meet label location and minimum type size requirements.

4. All nutrient levels claimed on the Information Panel for the retail product will be subject to analytical verification by FDA laboratories.

5. In addition to specifying the nutrient claims that can be madc in labeling, the regulations also restrict or prohibit claims of health and medical benefits in labeling and advertising.

Headings, Sequence, and Contents

The headings, sequencing and contents prescribed for incorporating nutrition information into food label information panels are as follows:

1. *Nutrition Information.* This is the mandatory heading. The term "per serving" may be optionally included beside or beneath the mandatory heading.

2. *Serving (Portion) Size.* A "normal" serving size must be defined in terms of easily recognized household units or terms. The serving size is to be an amount

that could be practically consumed at a meal by a young adult male who engages in light physical activity. For items like flour and sugar, which are used only as food ingredients, the term "Portion" may be substituted for "Serving".

3. *Servings (Portions) Per Container.* The requirement to accompany serving size definition with servings per package is intended to discourage manipulation of serving size for the purpose of apparent nutritive value. *(Note: Nutrient values claimed on the label subsequent to the above headings must be on a per serving or, where appropriate, per portion basis and must apply to the product as purchased. A second column of nutrient values may be provided (a) for foods "as prepared" (e.g., cake mix) where explicit recipe and cooking instructions are given, (b) for foods "as eaten" (e.g., cereal and milk) where the food is not normally consumed directly or (c) for amounts of the food eaten per day (e.g., milk or bread) where intake of multiple servings per day can be documented).*

4. *Calories.* Values must be listed in 2-Calorie increments up to 20 Calories per serving, in 5-Calorie increments from 20 to 50 Calories per serving, and in 10-Calorie increments above 50 Calories per serving.

5. *Protein.* Values to the nearest whole gram per serving must be listed. For products whole protein quality, as determined by Protein Efficiency Ratio (PER), is less than 20% that of casein, the statement "not a significant source of protein" must be inserted in place of grams per serving.

6. *Carbohydrate.* Values to the nearest gram per serving must be listed.

7. *Fat.* Values to the nearest gram per serving must be listed.

8. *Fatty acid information (optional).* It may be included on the nutrition panel if the product is comprised of 10% or more fat (dry-weight basis) and if the product provides 2 grams or more of fat per serving. The incorporated claims would include the following:

a) Percent of calories from fat;
b) Polyunsaturated fat – nearest gram per serving;
c) Saturated fat – nearest gram per serving; and,
d) "Information on fatty acid (and/or cholesterol) content is provided for individuals, who on the advice of a physician, are modifying their total daily intake of fat (and/or cholesterol)." This is a required statement on all labels which carry fatty acid or cholesterol information.

9. *Cholesterol (optional).* When declared, this must be stated in milligrams per 100 grams of food and milligrams per serving. Cholesterol values may be incorporated with or without accompanying fatty acid values, provided the appropriate footnote in (d) above is used.

10. *Sodium (optional).* When declared, this also must state milligrams per 100 grams of food as well as milligrams per serving. Sodium content values, but not fatty acid or cholesterol values, may be listed on the label without triggering mandatory nutrition labeling.

11. *Percentage of U.S. Recommended Daily Allowances (U.S. RDA).* All labels which carry nutrition information must list percentage of U.S. RDA values for protein and seven "key" vitamins and minerals. Twelve other vitamins and minerals have FDA-adopted U.S. RDA values and any of these that are indigenous to the food ingredients may be included in the label list of eight key nutrients; any of these that have been added to the product must be listed.

The U.S. RDA for each vitamin and each mineral, except calcium and phosphorus, is the highest RDA value established by the National Research Council of the National Academy of Science for any age-sex category, excluding pregnant or lactating females. The high values were selected to help ensure that 100% U.S. RDA would provide the RDAs of essentially all persons. (U.S. RDA values for infants under 1 year, children under 4 years and for pregnant or lactating women are defined for use in labeling of foods targeted exclusively to these groups.)

Nutrients declared in terms of the U.S. RDA must be listed in increments of 2% from 2 to 10% U.S. RDA, in 5% increments from 10 to 50% U.S. RDA and in 10% increments thereafter. Any of the eight key nutrients present at less than 2% U.S. RDA must still be listed, in tabular or footnote form, and declared "O" or as "contains less than 2% U.S. RDA of (these) nutrient(s)." If other vitamins and minerals are to be listed, all eight key nutrients must be tabulated. All vitamins and minerals added as fortification must be listed. Others would presumably be listed only if naturally present at 2% U.S. RDA per serving or greater.

Regulation Enforcement

Any product which carries nutrition information will be subject to FDA laboratory analyses for all nutrients claimed to be in the packaged product. To be "in compliance", labeled products must meet three criteria:

1. For essential nutrients which have been added to the product (such as specific vitamins or minerals), FDA's analytical value(s) for a composite sample from 12 packages of one lot of the product must equal or exceed label claims;

2. For essential nutrients that are indigenous to the product or its food ingredients, or for claimed polyunstaruated fat, the analytical values must equal or exceed 80% of the label claims; and

3. Analytical values for calories, carbohydrate, fat, saturated fat, cholesterol and sodium must not exceed 120% of the label claims.

Products not meeting these criteria may be declared misbranded.

In addition to these enforcement actions, which were designed to insure accuracy of the nutrition information, several regulatory precautions against nutrient horsepower races or promiscuous fortification have also been instituted. Claimed U.S. RDA values for specific nutrients must be listed in 2, 5, or 10% increments as described above. All values must be rounded to whole number units. A food must contain 10% U.S. RDA of a particular nutrient before the food can be called a "significant source". Likewise, an essential nutrient level in one food can be declared "superior" to that in another food only if the difference is 10% of the U.S. RDA. Foods which are fortified to contain 50% of the U.S. RDA per serving or greater are declared to be vitamin-mineral supplements and thereby subject to more rigid regulation.

General Recommendations

Based on the key provisions and compliance requirements, a list of precautions recommended to food manufacturers include:

1. Acquire first-hand knowledge of the applicable regulations referenced above.

2. For each product determine what label changes will be necessary to comply with Information Panel requirements.

3. Examine current labels for "nutrition claims" and current formulas for "added nutrients" which could invoke mandatory nutrition labeling.

4. Formulate a plan for:
   a) implementing Information Panels on all labels,
   b) implementing mandatory nutrition labeling, or if this is technically unfeasible, changing current claims or formulas to avoid mandatory labeling, and
   c) deciding whether or not to implement voluntary nutrition labeling on other products.

Factors which will affect decisions about adopting nutrition labeling include these considerations:

1. Internal expertise will need to be developed or consultant expertise retained to help assure compliance with technical and legal requirements of the regulations.

2. All nutrition claims must be based on analytical programs. Calculated data from handbook or literature averages likely impose unacceptably high risks of violation.

3. The initial baseline determination of nutrient levels will require statistically valid sampling and analysis plans and will impose significant expense. Cost of maintenance of continuing nutrient quality control will be lower but will depend on the number of nutrient claims made for the product and the frequency of testing dictated by nutrient variability.

4. Practical, deliberate approaches can minimize both expense and risk of violation. *Not* analyzing for nutrients expected to be present at trivial levels, making no label claim for nutrients that vary widely and use of statistical design to minimize numbers of assays and maximize levels of confidence are all justifiable to effect efficiency and economy.

Factors other than legal and technical considerations, must also be evaluated. Assessment of some of these includes:

1. That nutrition labeling should be a consumer service, not a product promotion device. Attempts to sell the nutrient characteristics of products seem unlikely to be successful and seem likely to lead to abuses that will trigger more repressive legislation and control on nutrition information and claims.

2. That nutrition labeling should be applied to all foods, where technically and economically feasible, not just the ones with "good" nutrient profiles. Nutrition labeling, when broadly applied, will help consumers prudently incorporate foods into the diet rather than include or exclude foods based on arbitary characterizations of "good" and "bad" or "nutritious" and "non-nutritious".

3. That Nutrition Labeling Regulations do not warrant vitamin-mineral fortification whose sole objective is enhancement of the product's nutritional image. Such practice may be interpreted as abuse of the regulations and trigger reactionary regulatory control.

The foregoing can be summarized with a single recommendation to approach nutrition labeling thoroughly, honestly, and with a consumer-oriented perspective. If this course is not feasible for a manufacturer, adoption of nutrition labeling should be delayed until significant industry experience identifies improved and simplified methods for implementing and controlling nutrition claims.

FEDERAL FOOD STANDARDS

All over the United States, if you buy mayonnaise, you can be sure you're getting essentially the same product. And if you buy USDA Choice beef, you can be sure it's the same quality. The various kinds of food standards set by the Federal Government make this possible.

FDA food standards of identity are mandatory or regulatory. They set requirements which products must meet if they move in interstate commerce. They protect against deception, because they define what a food product must consist of to be legally labeled "mayonnaise," for example.

USDA grade standards for food are voluntary. Federal law does not require that a food processor or distributor use the grade standards. The standards are widely used, however, as an aid in wholesale trading, because the quality of a product affects its price. The grade (quality level) also is often shown on food products in retail stores, so consumers can choose the grade that best fit their needs.

Food standards established by the Federal Government usually fall into two general classes--voluntary or mandatory. A third class consists of standards recommended for adoption by State and local governments.

Following is a listing of the principal kinds of Federal standards for food.

VOLUNTARY STANDARDS

U.S. Department Of Agriculture Grade Standards

Under authority of the Agricultural Marketing Act of 1946 and related statutes, USDA has issued grade standards for some 300 food and farm products.

Food products for which grade standards have been established are: beef, veal and calf, lamb and mutton; poultry, including turkey, chicken, duck, goose, guinea, and squab; eggs, manufactured dairy products, including butter, Cheddar cheese, and instant nonfat dry milk; fresh fruits, vegetables, and nuts; canned, frozen, and dried fruits and vegetables and related products such as preserves; and rice, dry beans, and peas. U.S. grade standards are also available for grains, but not for the food products, such as flour or cereal, into which grain is processed.

USDA provides official grading services, often in cooperation with State departments of agriculture, for a fee, to packers, processors, distributors, or others who wish official certification of the grade of a product. The grade standards also are often used by packers and processors as a quality control tool.

Federal law does not require use of the U.S. grade standards or the official grading services. Official grading is required under some State and local ordinances and some industry marketing programs.

Products which have been officially graded may carry the USDA grade name or grade shield, such as the familiar purple "USDA Choice" shield seen on cuts of beef or the "U.S. Grade A" on cartons of eggs. Grade labeling, however, is not required by Federal law, even though a product has been officially graded. On the other hand, a packer or processor may not label his product with an official grade name such as Grade A (even without the "U.S." prefix) unless it actually measures up to the Federal standard for that grade. Mislabeling of this sort would be deemed a violation of the U.S. Federal Food, Drug, and Cosmetic Act.

National Marine Fisheries Service Grade Standards

The U.S. Department of Commerce's National Marine Fisheries Service provides grade standards and grading services for fishery products similar to those provided by USDA for other foods. To date, 15 U.S. grade standards have been developed for frozen processed fishery products, covering such products as semi-processed raw whole fish, fish blocks, cut fish portions, steaks and fillets; breaded raw and precooked fish portions and sticks; raw headless and breaded shrimp; raw and fried scallops. Such products when produced and graded under the U.S. Department of Commerce inspection program may carry the USDC "Federally Inspected" mark and/or the U.S. grade shield. However, as under the USDA grading programs, grade labeling is not required by Federal law, even though products are officially inspected and graded.

MANDATORY STANDARDS

U.S. Department Of Agriculture Standards Of Composition And Identity

USDA has established minimum content requirements for Federally inspected meat and poultry products (usually canned or frozen) under the Federal Meat Inspection Act and the Poultry Products Inspection Act.

To be labeled with a particular name--such as "Beef Stew"-- a Federally inspected meat or poultry product must meet specified content requirements. These requirements assure the consumer that he's getting what the label says he's getting. They do not, however, keep different companies from making distinctive recipes. The USDA minimum content requirement for beef stew specifies the minimum percentages of *beef only* (25 percent) that the stew must contain. It doesn't keep the manufacturer from using combinations of seasonings or increasing the amount of beef to make his product unique.

USDA has also established complete standards of identity for these products: chopped ham, corned beef hash, and oleomargarine. They go further than the composition standards, setting specific and optional ingredients.

Food and Drug Administration Standards

The Federal Food, Drug, and Cosmetic Act provides for three kinds of mandatory standards for products being shipped across State lines: standards of identity, standards if minimum quality, and standards of fill of container. All these standards are administered by the Food and Drug Administration of the U.S. Department of Health, Education, and Welfare. The law sets forth penalties for noncompliance.

Standards of Identity

FDA standards of identity (like USDA's) establish what a given food product *is*—for example, what a food must be to be labeled "preserves." The FDA standards of identity also provide for use of optional ingredients in addition to the mandatory ingredients that make the product what it is. Standards of identity have eliminated from the market such things as "raspberry spread"—made from a little fruit and a lot of water, pectin, sugar, artificial coloring and flavoring, and a few grass seeds to suggest a fruit preserve.

FDA has standards of identity for a large number of food products (excluding meat and poultry products, which are covered by USDA).

Types of products for which standards of identity have been formulated by FDA include: cacao products; cereal flour and related products; macaroni and noodle products; bakery products; milk and cream products; cheese and cheese products; frozen desserts; food flavoring; dressings for food; canned fruits and fruit juices; fruit butters; jellies, preserves, and related products; non-alcoholic beverages; canned and frozen shellfish; eggs and egg products; oleomargarine and margarine; nut products; canned vegetables; and tomato products.

Standards of Minimum Quality

FDA standards of quality have been set for a number of canned fruits and vegetables to supplement standards of identity. These are minimum standards for such factors as tenderness, color, and freedom from defects. They are regulatory, as opposed to USDA grade standards of quality, which are for voluntary use.

If a food does not meet the FDA quality standards it must be labeled "Below Standard in Quality; Good Food--Not High Grade." Or, words may be substituted for the second part of that statement to show in what respect the product is substandard. The label could read, "Below Standard in Quality; Excessively Broken" or "Below Standard in Quality; Excessive Peel." The consumer seldom if ever sees a product with a substandard label.

When USDA grade standards are developed for a product for which FDA has a minimum standard of quality, the requirements for the lowest grade level USDA sets are at least as high as the FDA minimum. USDA grade standards for canned tomatoes, for example, are U.S. Grades A, B, and C. U.S. Grade C is comparable to FDA's minimum standard of quality.

Standards of Fill of Container

These standards tell the packer how full a container must be to avoid deception. They prevent the selling of air or water in place of food.

Where to Obtain Copies of Federal Standards

Any of the USDA or FDA standards may be obtained free of charge upon request from:

Consumer & Marketing Service
U.S. Department of Agriculture
Washington, D.C. 20250

or

Food and Drug Administration
200 C Street
Washington, D.C. 20204

FEDERAL SPECIFICATIONS

In selling to the U.S. Government, the canner must be familiar with the current Federal Specification for the product. These may be obtained from the U.S. Government Printing Office. The invitations to bids state the particular specification that applies.

Military Specifications may be obtained directly from:

The Naval Supply Depot
5801 Tabor Avenue
Philadelphia, Pa. 19120

INTERNATIONAL FOOD STANDARDS

International food products trade has reached such proportions that the need for unified international food standards has become evident and been recognized. In 1962, the Codex Alimentarius Commission was established under the auspices of the United Nations through the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). The Objectives of the Codex Alimentarius Commission are "to develop international and regional food standards, and publish them in a Codex Alimentarius, or food code." Included are to be "provisions in respect to food hygiene, food additives, pesticide residues, contaminants, labeling and presentation, mehtods of analysis, and sampling".

Participation in the Commission work and acceptance of Codex Alimentarius Standards is voluntary on the part of each country. The Commission has developed a number of standards which have received various degrees of acceptance by the different countries.

PRODUCT RECALLS

Responsibility for Product Recall

Legal responsibility for product safety and quality rests with all officers and employees of a food manufacturing company. The corporate officers specifically must bear the ultimate responsibility and must be prepared to act when action is needed. If hazardous or illigal products are placed on the market, the corporate officers may be subject to criminal prosecution.

The officials of a company must assume responsibility for developing and implementing the company's product recall procedure. When an emergency arises, they must give full support to the staff organization developed to execute recalls. Immediate action may be essential. Authority must be centralized.

FDA's Recall Policy

The FDA Policy ultimately governs what actions must be taken in recalls. It is essential therefore that corporate officers thoroughly understand what this policy is.

The Food and Drug Administration lists three classes of recalls, as follows:

Class I Recalls. Class I Recalls are used in emergency situations and involve removal from the market of products whose consumption could create either immediate or long-range, life threatening consequences through a direct cause-effect relationship. An example is the presence of *Clostridium botulinum* toxin in foods. Under such circumstances, the FDA requires that the recall be made to the customer level provided that it has reached that level, that the product be placed on the public recall list, and that a public warning be issued via a news media, if this would aid in the recall. The effectiveness check for a Class I Recall must assure 100% removal of all known direct accounts and sub-accounts, and, if necessary, removal of product in the possession of consumers.

Class II Recalls. Class II Recalls represent priority situations (as opposed to emergency situations for Class I Recalls) in which the consequences may be either immediate or long-range with possible or potential life threatening or hazardous-to-health situations. These might include such conditions as the presence of pathogenic microorganisms other than *C. botulinum* in foods, improper calibration of thermometers, and/or unnecessary exposure to radiation.

For a Class II Recall, FDA requires that the product be removed to the retail or dispensing level, that notice of the recall be placed on the public recall list, and when the public interest requires, that a press release announce the recall. The effectiveness check for such a recall would be made on the adequacy of the removal at levels reflecting the degree of consumer hazards associated with the violation.

Applicable to both Class I and Class II Recalls is the 21 CFR Part 90, Subpart B, 90.20 (f) requirement regarding a recall plan for thermally processed low-acid foods packaged in hermetically sealed containers.

Class III Recalls. Class III Recalls represent routine situations in which the consequences to life are remote or non-existent. These involve recalls due to adulteration not involving a health hazard or misbranding. They might also include defects in food relating to such factors as aesthetic qualities and label violations. Removal in these cases is made to the wholesale level and the recall is mentioned on the FDA public recall list. A press release ordinarily would not be issued, but FDA would consider each case in the light of the particular circumstances. Effectiveness checks for a Class III Recall are not as extensive as in Class I or II Recalls. However, FDA may request a firm to submit a statement attesting to the amount of the stock returned and dispostion of it.

Market Withdrawals. In addition to the three classes of recalls, the FDA procedure provides for Market Withdrawals. Market Withdrawals include removal from the market of products involving no violation or only minor violations not subject to legal actions under existing compliance policy. No effectiveness check is required for Market Withdrawals and these actions are not placed on the FDA weekly recall lists. Market Withdrawals are made when the product is still under complete control of the manufacturer.

The Weekly Recall List. Each week the Food and Drug Administration publishes a list of all recalls made during the previous week. Class I, II and III Recalls are mentioned which alerts the public and the press to such actions. Market Withdrawals are not mentioned. The press may use in any way the information contained on the recall list. Often the media produce their own news accounts about such products based on the facts contained in the list. This practice can create serious additional problems for packers involved in Class III Recalls even though the FDA did not issue a press release.

How to Avoid a Recall

The best way to avoid a speeding ticket is to drive within the posted speed limits. And the best way to avoid a recall is to operate in accordance with FDA regulations. These involve many different matters and packers need to become acquainted with them. Some of the conditions that may trigger recalls are: pathogenic microorganisms in the product, pesticide residue levels above tolerances, use of un-approved additives, contamination with heavy metals or other objectionable substances, processing to a potentially unsafe level, inaccurate labeling, failure to comply with FDA regulations for standards of quality, identity and fill of container, and failure to operate with FDA's good manufacturing practice regulations. A further means of eliminating the possibility of a recall would be for the quality control supervisor to be directly answerable to top management, such as the president, or a vice-president of the firm.

To help avoid recalls, it is desirable to seek and follow the advice of a reliable source of information about FDA regulations such as the National Canners Association. In 1974 the NCA revised and up-dated its Bulletin 34-L, entitled "Organizing a Product Recall Program." U.S. Food and Drug Administration has advised NCA that Bulletin 34-L meets requirements of Part 90 rules of the Good Manufacturing Practice Regulations for a recall program. Copies of Bulletin 34-L may be obtained for a nominal fee by writing to:

National Canners Association
1133 20th St., N.W.
Washington, D.C. 20036

MICROBIOLOGY OF CANNED FOODS

Basic Considerations on pH Value

One of the most important properties associated with food chemistry and with microbiological food spoilage is the intensity of the acidity, or the pH of the product. This intensity factor, of pH value, is not to be confused with the amount of acid present in the food. In order to state this intensity of the acidity in simple numerical terms a mathematical notation was developed and named the pH scale. This scale runs from 0 to 14. The neutral point at which a substance is neither acidic nor basic is at pH 7.0. The smaller values of pH denote greater acid intensities and the larger numbers denote the less acidic or the basic intensities.

pH of foods depends upon many factors, some of these being maturity of the product, variety, and growing conditions. For these reasons, the pH of food is usually within a range of values.

Influence of pH on Food Microbiology and Spoilage

Different species of microorganisms are characterized by a specific pH value for optimum growth. Other chemical and physical characteristics of the food are also factors that affect the growth rate of bacteria, yeasts, and molds. One important effect of pH is its influence upon resistance of bacteria to heat. The lower the pH value, i.e., the higher the acid intensity, the lower the resistance of bacteria and bacterial spores to heat at a given temperature. When there are several species of bacteria, yeasts, and molds in a food, the pH value of the food is one of the most important factors determining which of those types of microorganisms will multiply faster, and within the types, the species that will prevail. That characteristic of pH is important both in industrial fermentations and in food spoilage considerations.

Effect of Temperature on Growth of Microorganisms

While in the actively growing stages, most microorganisms are readily killed by exposure to temperatures near the boiling point of water. Bacterial spores are more heat resistant than their vegetative cells.

Mean pH Values of Selected Foods

pH Value	
2.3	Lemon juice (2.3)*, Cranberry sauce (2.3)
3.0	
	Rhubarb (3.1)
	Applesauce (3.4), Cherries, RSP (3.4)
	Berries (3.0 – 3.9), Sauerkraut (3.5)
	Peaches (3.7), Orange juice (3.7)
	Apricots (3.8)
4.0	
	Cabbage, red (4.2), Pears (4.2)
	Tomatoes (4.3)
	Onions (4.4)
4.6	Ravioli (4.6)
	Pimientos (4.7)
5.0	Spaghetti in tomato sauce (4.9)
	Figs (5.0)
	Carrots (5.2)
	Green Beans (5.3), Beans with pork (5.3)
	Asparagus (5.5), Potatoes (5.5)
	Lima beans (5.9), Tuna (5.9, Tamales (5.9)
6.0	Codfish (6.0), Sardines (6.0), Beef (6.0)
	Pork (6.1), Evaporated milk (6.1)
	Frankfurters (6.2), Chicken (6.2)
	Corn (6.3)
	Salmon (6.4)
	Crabmeat (6.8), Milk (6.8)
	Ripe olives (6.9)
7.0	Hominy (7.0)

*Mean pH Value

Bacteria can be classified according to their temperature requirements for growth. Bacteria growing at temperatures between 75° and 100° F are called *mesophiles*. Other species of bacteria have optimum growth temperatures between 50° and 65° F and are called *psychrophiles*. Psychrophiles may grow, usually slower, at temperatures down to 35° F. Those that grow best between 120° and 150° F are *thermophiles*. Thermophiles may grow slowly up to 170° F.

There is an important difference between the optimum temperatures for growth of bacteria and their resistance to heat, i.e., to the effect of high temperatures. Highly heat resistant bacteria are called *thermoduric*. Mesophilic organisms can be thermoduric due to the high heat resistance of their spores, as can the spores of thermophilic bacteria.

Foods have associated microfloras. Certain microorganisms are usually found in certain food groups. These organisms gain entrance to the food during the canning operation either from the soil, from ingredients, or from equipment. On the basis of acidity classification of foods, it is possible to make general statements relative to the microorganisms which are potentially capable of producing spoilage in canned foods.

Acidity Classification of Canned Foods

Low-Acid Foods. Because *C. botulinum* will not grow at pH levels of 4.6 or below, foods in which it will grow have been categorized as "low-acid foods." In food processing regulations, low acid foods are defined as "any commercially processed food with a finished equilibrium pH value greater than 4.6 and a water activity greater than 0.85, but not including alcoholic beverages, and shall also include any normally low-acid vegetables or vegetable products in which for the purpose of thermal processing the pH value is reduced by acidification."

Meat, fish, poultry, dairy products, and vegetables except tomatoes, generally fall into a pH range of 5.0 to 6.8. While they are relatively non-acid, they do fall in the acid range of pH values. Figs and pimientos, as well as some manufactured foods such as spaghetti products, have pH values between 4.6 and 5.0.

High-Acid Foods. Foods with pH values of 4.6 and below are classified as "high-acid foods." High acid foods include fruits, tomatoes, rhubarb, berries, and fermented foods such as pickles and sauerkraut.

BOTULISM

Botulism is an intoxication caused by a toxin produced in foods by the microorganism called *Clostridium botulinum*. This organism is a rod-shaped, spore forming bacillus. It originally lives in and comes from the soil in all parts of the world. *C. botulinum* is an anaerobic bacterium. It does not grow in the presence of free oxygen nor on surfaces which support the growth of many other types of bacteria. This bacterium produces an exotoxin which is the most deadly neuro-paralytic toxin known.

Six types of *C. botulinum* have been described and are well known, i.e., Types A, B, C, D, E, and F. Each type produces a specific and somewhat different exotoxin, but each toxin produces similar type symptoms. Anti-toxins or serums are specific to the particular type of toxin, but polyvalent vaccines are available.

The intoxication is caused by ingestion of the exotoxin produced by the organism *C. botulinum*. It is not caused by the organism itself. The toxins are inactivated by heat in 10 minutes at 212° F. Types A, C and D are proteolytic, that is, they produce an extremely foul and putrid odor. Types B and E do not produce this odor.

C. botulinum is a gas producing organism but it is not a prolific gas former. Cans of food in which there are living organisms do not usually produce a "hard swell." Normally the type of swell is a "soft swell" or a "springer." In some cases, the cans may not swell at all. The optimum growth temperature of the botulism organism for the development of toxin is from 65° to 85° F. Five to ten percent salt content in a product, such as salt-cured meats and fish, will prevent the growth of *C. botulinum*.

Botulism Symptoms

Most outbreaks of botulism are dramatic, in that symptoms appear suddenly and progress rapidly. Symptoms usually appear within 8 to 72 hours after ingesting the toxin. Typical symptoms involve the nervous system and result in double vision, difficulty in swallowing, impaired speech, difficulty in breathing, and paralysis of the extremities. Death results usually from paralysis of the respiratory muscles and asphyxia. In addition, some botulism victims have shown symptoms of nausea, vomiting and constipation.

The illness is difficult to diagnose because at the onset, the symptoms of botulism are often confused with symptoms of other diseases and few physicians are familiar with the diagnostic techniques. By the time the nature of the illness becomes apparent it is usually too late for therapy. In botulism the only therapy known is the early administration of anti-toxin serum. Mortality varies with different outbreaks but the average in the U.S. is 25% at present, down from about 60% up to 1945.

Since 1925, four deaths have been reported from consumption of foods commercially canned in the United States. One death occurred in 1941, two in 1963, and one in 1971. These four fatalities occurred over a period during which consumers ate the contents of nearly 800 billion containers of canned food. This record supports the fact that properly processed canned foods are safe. The few exceptions, however, have been so tragic in their occurence and consequences that increased effort and diligence by the canner in preventing botulism outbreaks are mandatory. Adherence to the Good Manufacturing Practice regulations and good plant sanitation in processing low-acid canned foods constitute a safeguard against botulism outbreaks.

Botulism in Home-Canned Foods

Several deaths occur each year from botulism contracted through consumption of improperly home canned foods. Over 450 such deaths have occurred since 1920. Because botulinum spores are killed by heat, the culprit in home canning is under-sterilization, either by not using a high enough temperature or by processing for too short a time, or a combination of these conditions.

CHARACTERISTICS OF CANNED FOOD SPOILAGE MICROORGANISMS

Low-Acid Canned Foods

Flat sour producing thermophilic bacteria. Aerobic and facultative anaerobic. Spores highly heat resistant. Occur more in canned vegetables and in products high in starch content for which quality considerations necessitate a minimum of heat processing. Produce acid but not gas. Cans do not swell. Type species: *Baccillus stearothermophilus.*

Thermophilic anaerobic bacteria. Very heat resistant. Obligate anaerobic. Gas and acid producers. Cans swell. Type Species: *Clostridium thermosaccharolyticum.*

"Sulphide spoilage" thermophilic bacteria. "Sulfur stinkers." Food turns dark due to production of H_2S and formation of sulfide with iron containers. Cans usually remain flat due to solubility of H_2S in water. Type species: *Clostridium nigrificans.*

Putrefactive anaerobic bacteria. Mesophilic, spore-formers and gas-formers. Type species: *Cl. botulinum, Cl. butiricum,* etc. Destruction of spore of *Cl. botulinum* is minimum standard for processing low acid foods. Most species of this group are more heat resistant than *Cl. botulinum.*

Aerobic mesophilic sport-formers. As a group, they are less important than putrefactive anaerobes, due to (a) vacuum in canned foods which inhibits their growth, and to (b) inability to produce marked changes in foods. However, some species of this group have shown considerable heat resistance. Several species of *Bacillus* belong to this group.

Yeasts, molds, and non-spore-forming bacteria. Spoilage with these microorganism is very uncommon in low acid canned foods. Their presence would indicate: (a) gross understerilization; (b) contamination due to defective seam. These organisms are readily controlled by relatively short processes at temperatures below 212° F.

Acid Foods

Spore-forming bacteria. Among the most important are: (a) *Bacillus thermoacidurans*, which is aerobic, not very heat resistant, thermophilic, produces "flat sour", (b) *Cl. pasteurianum*, which is spore former, anaerobic, saccharolytic, gas-producing.

Non-sporing bacteria. Lactic acid producing bacteria: *Lactobacillus* and *Leuconostoc* sp. Some are gas producing. Develop best under conditions of reduced oxygen tension.

Yeasts. Due to their very low heat resistance, yeast cause spoilage in canned foods only in cases of gross under-processing or can leakage.

Molds. Molds are in general of insignificant importance in all canned foods. However, there is one exception in *Byssochlamys fulva*, which is an important factor in spoilage of canned fruits. It breaks down pectinous material, disintegrating fruit; sometimes it produces gas. Heat resistance: 30 minutes at 190° F, or 16 minutes at 212° F. This mold is unusually heat resistant in comparison to other molds.

Spoilage Resulting From Can Leakage

The organisms which cause spoilage in the event of leakage are the heterogeneous free-living forms not subject to orderly classification in relation to canned food groups. There is, however, an important biological differentiation between spoilage from under-sterilization and from leakage, as in the case of low-acid foods. In this group when spoilage occurs from under-sterilization it is due usually to a single spore-forming type. Where leakage is concerned, on the contrary, it is customary to find mixed cultured of nonsporing bacteria which could not have survived the process and which, therefore, must have entered the can after process. This differentiation does not exist in a clean-cut way in the case of the acid products because the aciduric organisms which cause spoilage may have been present in the product at the time of canning or may have entered subsequent to the process. Some guidance as to the cause of spoilage, however, may be had from observations as to whether spoilage occurred from one or a few or many bacterial types. In the latter instance leakage is indicated.

Commercial Sterility in Canned Foods

The very basis for the preservation of foods by canning is the use of heat to destroy bacteria which are generally capable of spoiling the product. Food poisoning bacteria are readily destroyed by heat. As a practical example of this fact, the pasteurization temperature for milk is about 143° F for 30 minutes, or 161° F for 15 seconds. The usual process or heat treatment given low acid canned foods of pH 4.6 or higher is equivalent to at least 3 minutes at 250° F. This heat treatment is more than sufficient to destory any food poisoning bacteria. It is also equivalent to more than 6 hours at 212° F and frequently affords much more lethality.

Acid foods of pH 4.6 or below will not support the growth of food poisoning bacteria. Tests have shown that not only are the food poisoning bacteria incapable of reproducing in acid foods but that large numbers deliberately added to such acid foods actually die in relatively short periods of time. Acid foods are not subjected to as much heat as low acid foods. However, they are heated sufficiently to destroy all vegetative bacterial cells, yeasts, and molds which could, if not destroyed, cause spoilage.

For all practical purposes, it may be considered that when a food is hermetically sealed in a container there will be included microorganisms which, unless they are subsequently destroyed, will thrive under the environmental conditions afforded and cause spoilage of the food. The destruction by heat of the organisms naturally present in the sealed container is the fundamental operation of food preservation by canning. The operation is known as processing to commercial sterility. The time and temperature combination at which the product is heated is known as the process.

The process is determined from a study of the rate of heat penetration for the product and from a study of the heat resistance of significant spores. A theoretical process is then calculated and tested by inoculation of product with a known spore load.

An example is the determination of a process for canned corn. Since it is known that flat sour and sulphide thermophiles as well as putrefactive anaerobic mesophiles cause spoilage of corn, it is necessary to study the conditions under which these agents are destroyed. After preparing a spore crop of each test organism, a heat resistance determination is made. By using thermocouples, the rate of heat penetration into canned corn is determined. Employing a mathematical correlation between heat resistance and heat penetration, we arrive at what is known as a "theoretical" process. To test this theoretical process, packs of corn are inoculated with the test organisms. The packs are processed at various temperatures for varying periods of time, ranging about the "theoretical process," and then incubated to determine the spoilage levels.

The inoculated pack technique valuable especially for products, such as spinach, which exhibit rather gross variations in their rate of heat penetration. If the inoculated pack results confirm the mathematically derived theoretical process, the mathematical methods can usually be applied to the product in a variety of can sizes, thus precluding the need for studying the effects of the process on experimental packs in each can size.

The process so determined will produce a COMMERCIALLY STERILE canned food product with the greatest retention of quality.

Commercial sterility in low-acid foods may be defined as "that process by which all *Clostridium botulinum* spores and all other pathogenic bacteria have been destroyed, as well as more heat resistant organisms which, if present, could produce spoilage under normal conditions of non-refrigerated canned food storage and distribution." If the number of organisms in the product is excessive, recommended processes may not be adequate to prevent spoilage. Therefore, it is essential to exercise strict principles of sanitation while the agricultural commodities are prepared for canning.

There are some thermophilic or heat-loving bacteria which produce spores of such high resistance to heat that they cannot be destroyed in some products without processing to such a degree that the canned product would be unmarketable.

Fortunately, the thermophilic bacteria are not infectious or poisonous and are therefore of no significance with respect to public health, since we know that large numbers are ingested in coffee sweetened with table sugar. When such thermophilic spores survive the process in canned foods, they are unable to germinate and cause spoilage at storage temperatures of 100° F or lower. Prompt cooling of processed cans to an average temperature of 100° F and avoidance of high temperature storage safeguards against spoilage by thermophilic bacteria. Incubation of low acid canned foods at 131° F will quite obviously allow germination with recovery of vegetative cells.

Microbial decomposition of canned foods may result from lack of commercially sterile conditions, or from contamination of can contents after processing.

MICROBIOLOGICAL STANDARDS FOR INGREDIENTS

In the analysis of ingredients, a wide variety of thermophilic and mesophilic bacteria are encountered. Relatively few of the mesophilic bacteria, however, are considered significant from the standpoint of food spoilage. In general, yeasts, molds and thermophilic bacteria are the significant spoilage types of organisms.

The types of thermophilic low-acid food spoilage spore forming bacteria which may be found are characterized into 3 groups—those which produce flat sour spoilage, i.e., *Bacillus stearothermophilus*, those which produce gas but not hydrogen sulfide, i.e., the thermophilic anaerobe *Clostridium thermosaccharolyticum*, and the thermophilic anaerobes which produce hydrogen sulfide spoilage, i.e., *Clostridium nigrificans*.

In general, there are no microbial standards by which the suitability of ingredients for use in canning may be measured. An exception to this are the standards suggested by the National Canners Association for thermophilic spore contamination of sugar and starch to be used in low-acid, heat processed canned foods. Those standards follow.

Standards for Starch and Sugar (National Canners Association)

A. Total thermophilic spore count: Of the five samples from a lot of sugar or starch none shall contain more than 150 spores per 10 g, and the average for all samples shall not exceed 125 spores per 10 g.

B. Flat sour spores: Of the five samples none shall contain more than 75 spores per 10 g, and the average for all samples shall not exceed 50 spores per 10 g.

C. Thermophilic anaerobe spores: Not more than three (60 percent) of the five samples shall contain these spores, and in any one sample not more than four (65 + percent) of the six tubes shall be positive.

D. Sulfide spoilage spores: Not more than two (40 percent) of the five samples shall contain these spores, and in any one sample there shall be no more than five colonies per 10 g (equivalent to two colonies in the six tubes).

CONTAINERS FOR CANNED FOODS

Canners of low-acid foods should comply with the requirements of Part 128b, Good Manufacturing Practices, promulgated by the U.S. Food and Drug Administration.

Under the regulations, the definition of an "hermetically sealed container" is as follows: "Hermetically sealed container means a container which is designed and intended to be secure against the entry of microorganisms and to maintain the commercial sterility of its contents after processing".

The container is an essential factor in the preservation of foods by canning. After canned foods are sterilized, it is the container that protects the canned food from spoilage by recontamination with microorganisms. It is then most important for the success of the canning operation to use good quality, reliable containers and properly adjusted capping machines. Thus, the seams and closures produced will be within the strict tolerances necessary to prevent access of microorganisms into the container during the cooling operation and during the shelf life of the product.

The food processor must adhere closely to can manufacturers recommendations on tolerances for can seam dimensions. He must also carefully control the finish and closure dimensions of the glass containers used, to make sure that they agree with the measurements that have been found to produce tight and safe glass containers. Container manufacturers assist food processors in the selection of the most efficient container for specific food products, and in the selection, operation, and maintenance of closing machines.

The can manufacturers warranty the performance of the cans, covers and sealing compounds for each product application. They also sell and lease closing machines for the cans and provide technical services to their customers, using traveling representatives from their R&D Departments who make periodic visits. In addition, the can manufacturers have machinery service men making regular visits to canneries during their season to assist with general maintenance of closing machinery and to instruct the canners' personnel in the proper procedures for checking seams, replacing parts, etc. It is important to note here, however, that the can maker does not take the responsibility for the top seam. It is a general practice to offer a one year warranty on cans for standard type products although the anticipated shelf-life on most canned items is considerably longer. When sold by the can maker, closing machines carry a one year warranty on performance and parts except on those parts which normally wear and must be replaced by the canner.

TIN PLATE CANS

Recommended Can Sizes

In earlier years a large assortment of cans were used for fruits and vegetables. This was confusing to consumers and burdensome to canners. Through its Committee on Simplification of Containers, the National Canners' Association worked toward a resonably small list of cans. In 1934 the first simplified practice recommendation was promulgated by the National Bureau of Standards. The list was revised in 1937 and the latest one was promulgated in 1949. This last list recommends a total of 32 can sizes but for each product only a few sizes are permitted.

The following recommended can sizes, names dimensions, and designated use, were presented to and accepted by canners, can manufacturers, wholesale and retail grocers, consumer groups and other interested parties in late Summer 1948. On June 1, 1949, the list was promulgated as Simplified Practice Recommendations R155-49 by the Commodity Standards Division, National Bureau of Standards, (now "Office of Technical Services") U.S. Department of Commerce.

For each product there is a particular kind of can that is best suited and cheapest. The specifications include the weight and type of the steel base plate, the amount of tin coating and the manner of application (electrolytic or differential-coating), and the kind of enamel (if any).

In 1970 the National Canners Association submitted a package proposal to the National Bureau of Standards seeking the establishment of 16 separate Voluntary Products Standards for certain commodity and commodity groups.

In 1972, because of various policy decisions, the National Bureau of Standards decided to discontinue the program. At that time, the NBS noted there is no undue proliferation of can sizes in the industry. Even though work with the NBS has ended the 16 Recommended Product Standards remain a voluntary industry effort.

Can Name	*Dimensions*[1]	*Products*
2Z Mushroom	202 x 204	Mushrooms
—	202 x 214	Baby Foods
6Z	202 x 308	Juices (except Pineapple Juice), Mushrooms, Tomato Paste
—	202 x 314	Citrus and Grape Juice
4Z Pimiento	211 x 200	Olives, Pimientos
—	211 x 210	Baby Foods, Dry Beans, Spaghetti
4Z Mushroom	211 x 212	Mushrooms
8Z Short	211 x 300	Dry Beans, Tomato Sauce
8Z Tall	211 x 304	Fruits, Juices, Olives, Soups, Spaghetti, Vegetables
No. 1 (Picnic)	211 x 400	Dry Beans, Kraut Juice, Mushrooms, Soups, Vegetables
211 Cyl.	211 x 414	Juices, Pineapple, Prunes (dried)
Pt. Olive	211 x 600	Olives
7Z Pimiento	300 x 206	Pimientos
— —	300 x 308	Dry Beans
8Z Mushroom	300 x 400	Mushrooms
No. 300	300 x 407	Asparagus, Citrus Segments, Cranberries, Dry Beans, Juices (except Pineapple Juice), Pimientos, Spaghetti
No. 1 Tall	301 x 411	Fruits (except Pineapple), Vegetables, Olives
303	303 x 406	Dry Beans, Fruits (except Pineapple), Hominy, Soups, Vegetables
303 Cyl.	303 x 509	Soups
No. 1 Flat	307 x 203	Pineapple
Kitchenette	307 x 214	Dry Beans
No. 2 Vac.	307 x 306	Vegetables (vacuum packed)
No. 95	307 x 400	Dry Beans, Snap Beans (Asparagus style)
No. 2	307 x 409	Dry Beans, Fruits, Hominy, Juices, Vegetables
Jumbo	307 x 510	Asparagus, Dry Beans, Mushrooms
No. 2 Cyl.	307 x 512	Juices (except Pineapple Juice), Soups
Qt. Olive	307 x 704	Olives
No. 1¼	401 x 207.5	Pineapple
No. 2½	401 x 411	Dry Beans, Fruits, Hominy, Kraut Juice, Olives, Pimientos, Soups, Vegetables
No. 3 Vac.	404 x 307	Sweet Potatoes
No. 3 Cyl.	404 x 700	All Products (except Pineapple)
No. 10	603 x 700	All Products

[1] In the statement of each dimension, the first digit gives the number of whole inches, and the second and third digit gives the fraction expressed in sixteenths of an inch. Thus 211 x 400 means that the can is 2-11/16 inches in diameter and 4 inches high. These dimensions apply only to regular type sanitary or open-top cans.

Characteristics of Cans Used for Canned Food Products

The following table gives the main characteristics of cans and the can size used for some of the more important canned foods. The table was compiled by American Can Co., and up-dated to 1974.

CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

Product	Common Can Sizes	Tin Coating		Inside Enamel Coating		Type Steel	
		Body	Ends	Body	Ends	L	MR
Apple Slices	603 x 700	50-25	25	PL	E		X
	307 x 409						
	303 x 406						
Apple Butter	603 x 700	75-25	75-25	E*	E	X	
	401 x 411						
	303 x 406						
Apple Juice	404 x 700	50-25	25	EE*	EE	X	
	202 x 308						
	202 x 314						
Applesauce	303 x 406	50-25	25	PL	E		X
	603 x 700						
	211 x 304						
Apricots	401 x 411	50-25	25	PL	E		X
	303 x 406						
	603 x 700						
Asparagus	303 x 406	135-25	25	PL	E		X
HFT Side Seam	211 x 400	25	25	E	E		X
	603 x 700						
Beans, Green	303 x 406	100-25	25	PL	E		X
HFT Side Seam	603 x 700	50-25	50-25	E*	E		X
	211 x 304	25	25	E	E		X
Beans, Lima	303 x 406	25	25	E	E		X
	603 x 700						
	211 x 304						
Beets	303 x 406	50-25	50-25	E*	E		X
	603 x 700						
	211 x 304						
Blackberries and Similar Berries	303 x 406	75-25	75-25	E*	E	X	
	603 x 700						
	211 x 304						
Blueberries	300 x 407	100-25	100-25	E*	E	X	
	300 x 108						
	603 x 700						
Carrots	303 x 406	50-25	50-25	E*	E		X
	603 x 700	75-25	25	PL	E		X
	211 x 304						
Cherries, R.S.P.	303 x 406	75-25	75-25	E*	E	X	
	603 x 700						
	307 x 409						

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CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

Product	Common Can Sizes	Tin Coating		Inside Enamel Coating		Type Steel	
		Body	Ends	Body	Ends	L	MR
Cherries, Sweet, Dark and Light Color	303 x 406 603 x 700 211 x 304	75-25	75-25	E*	E	X	
Light Color Only		100-25	25	PL	E	X	
Corn	303 x 406 307 x 306 603 x 700	25	25	E	E		X
Fruit Cocktail	303 x 406 401 x 411 603 x 700	50-25	25	PL	E		X
Fruit Jellies							
Colored Fruit Including Apple	603 x 700 401 x 411 303 x 406	75-25	75-25	E*	E	X	
Light Colored Fruit-Except Apple		75-25	25	PL	E	X	
Fruit Salad	303 x 406 603 x 700 401 x 411	50-25	25	PL	E		X
Grape Juice	404 x 700 202 x 314 202 x 308	75-25	25	EE*	EE	X	
Grapefruit Juice	404 x 700 307 x 409 202 x 314	75-25	75-25	PL	PL		X
Mushrooms	211 x 212 202 x 204 211 x 300	50-25	25	PL	E		X
Okra	303 x 406 603 x 700 211 x 304	100-25	25	PL	E	X	
Olives, Ripe or Green Ripe	301 x 411 300 x 407 211 x 200	25	25	E*	E		X
Onions	211 x 304 603 x 700 303 x 406	50-25	50-25	E*	E		X
Orange Juice	404 x 700 211 x 212 307 x 409	75-25	75-25	PL	PL		X

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CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

Product	Common Can Sizes	Tin Coating Body	Tin Coating Ends	Inside Enamel Coating Body	Inside Enamel Coating Ends	Type Steel L	Type Steel MR
Peaches	401 x 411 303 x 406 603 x 700	50-25	25	PL	E		X
Pears	303 x 406 401 x 411 603 x 700	75-25	25	PL	E		X
Peas	303 x 406 603 x 700 211 x 304	25	25	E	E		X
Peas, Field	300 x 407 303 x 406 603 x 700	25	25	E	E		X
Pickles	603 x 700 303 x 406 211 x 304	100-25	100-25	EE*	EE	X	
Pimientos	300 x 206 211 x 200 401 x 411	50-25	25	PL	E		X
Pineapple	307 x 409 603 x 700 211 x 414	75-25	75-25	PL	PL		X
Pineapple Juice	404 x 700 211 x 414 307 x 409	75-25	75-25	PL	PL		X
Plums, Dark	401 x 411 603 x 700 303 x 406	75-25	75-25	E*	E	X	
Potatoes, White	303 x 406 603 x 700 300 x 407	25	25	E	E		X
Pumpkin (Squash)	303 x 406 401 x 411 603 x 700	50-25	50-25	E	E		X
Raspberries	303 x 406 603 x 700 211 x 304	75-25	75-25	E*	E	X	
Sauerkraut	303 x 406 401 x 411 603 x 700	100-25	25	PL	E	X	

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CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

		Tin Coating		Inside Enamel Coating		Type Steel	
Product	Common Can Sizes	Body	Ends	Body	Ends	L	MR
Spinach	303 x 406 603 x 700 401 x 411	25	25	E	E		X
Sweet Potatoes	404 x 307 603 x 700 303 x 406	50-25	50-25	E*	E		X
Tomatoes HTF Side Seam	303 x 406 603 x 700 401 x 411	75-25 25	75-25 25	E* E	E E		X X
Tomato Catsup HTF Side Seam	603 x 700	75-25 25	75-25 25	E* E	E E		X X
Tomato Juice HTF Side Seam	404 x 700 202 x 308 303 x 406	50-25 25	25 25	EE* E	EE E		X X
Tomato Paste HTF Side Seam	603 x 700 401 x 411 303 x 406	75-25 25	75-25 25	E* E	E E		X X
Tomato Puree HTF Side Seam	603 x 700 401 x 411 303 x 406	75-25 25	75-25 25	E* E	E E		X X
Hominy	300 x 407 401 x 411 303 x 406	25	25	E	E		X
Spaghetti in Tomato Sauce	401 x 602 211 x 410 404 x 309	25	25	E*	E		X
Beans with Pork in Tomato Sauce	300 x 407 307 x 214 307 x 510	25	25	E	E		X
Meat Stews	404 x 309 300 x 407 211 x 300	25	25	E	E		X
Chili Con Carne	300 x 407 211 x 300 404 x 309	25	25	E	E		X
Corned Beef		25	25	E	E		X
Potted Meat Drawn bodies for aluminum	208 x 108 208 x 207 208 x 201	A1 25	A1 25	E E	E E		 X

For symbols see footnotes page 120. Table Continued on Next Page

CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

		Tin Coating		Inside Enamel Coating		Type Steel	
Product	Common Can Sizes	Body	Ends	Body	Ends	L	MR
Pork and Gravy	404 x 200 401 x 211 404 x 700	25	25	E	E		X
Chicken, Boned	307 x 109 404 x 700 303 x 109	25	25	EE	EE		X
Ham, Refrigerated Aluminum Anode On One End	710 x 506 x 300 K.O 904 x 606 x 308 K.O. 512 x 400 x 211 K.O	25	25	E*	E		X
Meat, Luncheon, Normal Storage Temperature	314 x 202 x 304 K.O 314 x 202 x 201 K.O.	25	25	E*	E		X
Refrigerated Aluminum Anode On One End	400 x 400 x 1100 K.O.	25	25	E	E		X
Mackerel	607 x 406 x 108#1 Oval 211 x 300 202 x 308	25	25	E	E		X
Herring	607 x 406 x 108#1 Oval 300 x 407	25	25	E	E		X
Salmon	301 x 411 307 x 200 301 x 106	25	25	E	E		X
Sardines in Oil Drawn bodies both aluminum and tin plate	405 x 301 x 014.5	A1	A1	E	E		X
		25	25	E	E		X
Sardines in Tomato Sauce or in Mustard Sauce Drawn bodies both aluminum and tin plate	405 x 301 x 014.5	A1	A1	E	E		
		50-25	25	E	E		X
Tuna	307 x 113 211 x 109 401 x 205	25	25	E	E		X
Clams	307 x 202 404 x 700 211 x 400	25	25	E	E		X
Oysters	211 x 400 211 x 300 211 x 304	25	25	E	E		X
Fish Roe	211 x 400 211 x 203 208 x 314	25	25	E	E		X

For symbols see footnotes page 120. Table Continued on Next Page

CHARACTERISTICS OF CANS USED FOR CANNED FOOD PRODUCTS

		Tin Coating		Inside Enamel Coating		Type Steel	
Product	Common Can Sizes	Body	Ends	Body	Ends	L	MR
Crab Meat	307 x 200 307 x 113 401 x 211	25	25	EE	EE		X
Lobster	211 x 400 211 x 203 208 x 314	25	25	EE	EE		X
Shrimp	307 x 113 211 x 300 301 x 106	25	25	E*	E		X

PL - Plain
E - Single coat enamel
EE - Double coat enamel

* - Inside side stripe of enamel
A1 - Aluminum can
HTF - High tin fillet

Truck Trailer Shipping of Empty Cans

In the past, cans were shipped from the can manufacturing plant, to the packer, in various ways such as bulk cans in trailers, in cartons, or in bags. Today, many canners are receiving empty cans bulk palletized.

Bulk palletization was a method developed to economically and efficiently handle vertically stacked tiers of empty cans on wooden pallets. The wood pallets measure 5" x 44" x 56". Cans are mechanically loaded on the pallets, in the can manufacturing plants. The number of tiers per pallet can be decreased or increased depending upon conditions, i.e., truck size, customer door heights, etc. The average finished pallet measures approximately 53" high x 44" wide x 56" long for a single high pallet, and 106" high x 44" wide x 56" long for a double high pallet.

A sheet of tough fiberboard separate each tier of cans and acts as a floor for each tier above. In some instances, the loaded pallet is completely wrapped with corrugated board which protects cans from dust and dirt and further braces the cans for warehouse stacking. The pallet shrouds are then taped, strung or strapped prior to shipping. If the pallet is not wrapped, the method of shipping is to place a wooden frame over the top separator sheet and apply strapping.

The loaded pallets are picked up in the warehouse by fork trucks and delivered to trailers at the loading platform. Here the pallets are loaded into the trailer by means of fork trucks or are lowered onto roller conveyors installed on the floor of the trailer.

At the packers plant, the pallet can be unloaded from trailers by two (2) methods:

1. Fork truck to warehouse storage, or

2. Conveyed directly to the can depalletizer by means of an automatic conveyor system.

In warehouse storage, palletized cans will increase storage capacity by approximately 18%. (Compared to receiving cans in reshippers). In storage, palletized cans are more economically and efficiently handled. Loaded pallets can be stacked one atop of the other to full ceiling height. Transit in and out of the storage warehouse by fork truck is fast.

PALLETIZED CANS IN TRAILERS

CAN SIZE	CANS/ PALLET	CANS/ LAYER	LAYERS	O.A.H (a) IN TRLR INCHES	CANS/ TRAILER (b)
211x304	11,160	360	31	107-1/4	200,880
	10,440	360	29	100-3/4	187,920
	5,400	360	15	107-3/4	194,400
	5,040	360	14	101-1/4	181,440
211x400	9,000	360	25	106-3/8	162,000
	8,280	360	23	98-3/8	149,040
	4,320	360	12	106	155,520
	3,960	360	11	98	142,560
300x407	6,732	306	22	104	121,176
	6,426	306	21	99-1/2	115,668
	3,366	306	11	107-1/2	121,176
	3,060	306	10	98-3/4	110,160
303x406	6,256	272	23	107	112,608
	5,712	272	21	98-1/4	102,816
	2,992	272	11	107-1/8	107,712
	2,720	272	10	98-1/4	97,920
307x306	6,496	224	29	104-3/8	116,928
	6,272	224	28	101	112,896
	3,136	224	14	104-3/4	112,896
401x411	3,402	162	21	104-3/4	61,236
	1,620	162	10	103-3/4	58,320
404x700	2,100	150	14	104-1/8	37,800
	1,950	150	13	97-1/8	35,100
	1,050	150	7	107-3/4	37,800
	900	150	6	93-3/4	32,400
603x700	952	68	14	104-1/8	17,136
	884	68	13	97-1/8	15,912
	476	68	7	107-3/4	17,136
	408	68	6	93-3/4	14,688

a O.A.H. indicates overall height of the pallet(s) in trailer.
b Cans/trailer based on 45' trailer, 110" high (door openings).
Note: Sufficient clearance (difference in trailer height and overall height of the pallets) should be allowed on the trailer so that the pallets can readily be unloaded without damage.

Carload Shipping of Empty Cans

The following are the maximum capacities of standard, 40-ft box cars for the can sizes shown, when loaded as indicated. The information has been supplied by the Association of American Railroads and by American Can Company.

1) Bulk loading, with load extending to doorposts and bulkheads at that point, with can lids loaded in doorway between bulkheads:

No. 303	140,000 cans
No. 2½	60,000 cans
No. 10	15,000 cans
46 oz.	50,000 cans

2) When cans are shipped in paper carrier bags, load extending from end to end of car:

No. 303	160,000 cans
No. 2½	80,000 cans
No. 10	20,000 cans
46 oz.	60,000 cans

3) When loaded on pallets 44 x 56 inches size, load extending 50 to 54 inches high; 38 pallets are loaded in a 40-ft car and 48 pallets in a 50-ft car, with the following number of cans per pallet:

No. 303	2,720 cans per pallet
No. 2½	1,620 cans per pallet
No. 10	408 cans per pallet
46 oz.	966 cans per pallet

The empty fiberboard container for the can sizes mentioned have the following dimensions:

	Inches		
	Length	Width	Depth
No. 303 (12 cans)	12–3/4	9–9/16	4–3/8
No. 303 (24 cans)	12–3/4	9–9/16	8–3/4
No. 2½ (24 cans)	16–1/4	12–3/16	9–3/8
No. 10 (6 cans)	18–9/16	12–3/8	7
46 oz. (12 cans)	17	12–3/4	7

CAN CORROSION

The canning industry is a highly competitive industry operating for the most part on a very small profit margin where small cost variations may be a major factor. The best container from a technical viewpoint is of necessity a compromise to successfully meet all the requirements and in addition further compromise is very often necessary to satisfy the all important requirement that the container be the soundest economic choice.

Much progress has been made in the technical aspects of packaging since the early years of canning, yet the criterion for successful packaging is essentially the same today, namely, that the canned product must remain in a wholesome condition for the normal expected shelf life of the particular product. There being no objective standards for most of the details, the normal shelf life expectancy is established collaboratively by can supplier and packer through research pack tests, and commercial experience. As progress is made in packaging a particular product, the performance factor which limits the shelf life very often changes. For example, the limiting performance factor for soft drink product shelf life changed from perforation failure in the early stages of development of a tinplate package to iron pick-up tolerance in today's package.

It has been estimated that in excess of two thousand products are successfully packaged in metal containers. Containers for this wide variety of products must satisfy a number of internal and external corrosion requirements. The effective corrosivity of any particular product may vary due to both natural or formulation causes and those related to the canning operation.

External corrosion is governed in general by the same factors which are responsible for the atmospheric corrosion of metals. The internal corrosion of cans, however, differs because practically no air or at least only limited air is present. How these factors and others influence the corrosion problems can best be brought out by successively discussing the problem areas, the controlling factors, and means of control.

Internal Corrosion

Perforations are pinholes through the container metal caused by localized corrosion of iron. These type failures are to be avoided because not only is the individual can lost but also secondary spoilage of other cans is possible through exterior corrosion by the spilled product.

Springers or swells. Springers or hydrogen swells are evidenced by a bulging of the can ends caused by hydrogen gas formation. Although the product may be satisfactory, springers are unacceptable because product spoilage is usually associated with the same external appearance. Very often hydrogen swells are accompanied by excessive detinning in a plain can and certainly by high iron solution in a plain or organic-coated can.

Detinning is dissolution of tin from the tinplate surface and although usually associated with plain tinplate, may take place through enamel films. A reaction resulting in general overall etching of the tinned surface is expected with some products and is acceptable; however, localized detinned areas where black appearing base metal is exposed may not be acceptable. Product bleaching or color loss usually accompanies detinning and certain flavor changes may also occur. These changes are desirable for some products but not for others.

Rusting is the formation of loosely adhering, reddish-brown ferric oxide corrosion product on the corrosion site. Rust formation requires an excess of oxygen and thus when present in a can is usually found in the headspace area. Corrosion will continue under the rust layer and if sufficient corrosion capacity is available, perforation will result. Rust in itself is unsightly and may drop into and contaminate the product.

Enamel lifting is detachment of the organic film from the plate surface. Bubbles or loose flaps of film may be formed and film detachment is usually accompanied by mild corrosion at the area of detachment; base metal may be exposed resulting in increased corrosion. The possibility that particles or organic coating may drop into and contaminate the product is always present when lifting occurs.

Staining is adherent gray-black tin sulfide formation on the plate surface and occurs under organic films as well as on plain tinplate. Dark tin sulfide deposits appear about the same as base metal exposed through detinning and are just as objectionable.

Discoloration or formation of loose black iron sulfide which occurs in the headspace is the reaction product of exposed iron and hydrogen sulfide. When it forms on an organic-coated surface, it forms on the surface of the organic coating, and not at the plate surface. Formation of large quantities of iron sulfide usually results in black deposits on the product as the deposits are very loose.

External Corrosion

Rusting is formation of loosely adhering reddish-brown ferric oxide (Fe_2O_3) at pores in the tin coating. Rusting may occur during processing because of corrosive water conditions, during storage because of poor warehouse conditions, or during shipment because of poor transportation facilities. Perforations due to exterior corrosion are unlikely even with the thinnest tin coated plates but rusty appearance of the cans, especially rust spotting through paper labels, is very objectionable.

Detinning, dissolution of tin from the tinplate surface, may result in localized base steel exposure or in a general over-all surface etching, depending upon severity of the reaction and cause of attack. Detinning can be caused by alkaline retort water or alkaline rinse water and can also be caused by rusty equipment in electrochemical contact with cans. Appearance of the can may be readily degraded further because corroded areas are more susceptible to subsequent attack.

Staining is formation of any surface change other than detinning or rusting which interferes with normal bright appearance of the tin surface.

CORROSION ATTRIBUTABLE TO CANNING PRACTICES

Fill and Vacuum

Maintenance of proper fill of the container is of great importance in controlling corrosive influences. A well balanced fill must be attained. The headspace should be large enough to provide an adequate reservoir for hydrogen formation; but it should not be so large that excessive air is left in the can to promote corrosion.

For many products, control of headspace, in itself, is not enough. To obtain high initial vacuum, headspace control must be supplemented by removal of gases contained in the product and in the headspace. Adequate thermal exhausting, maintenance of high closing temperatures, effective vacuum syruping, or efficient vacuum or steam closure lead to the production of internal vacuum and thereby improve the life of the container and the quality of the product. Excessive air trapped within the can, as the result of inadequate exhausting or ineffective syruping or closure, leads to rapid corrosion of the can, product discoloration and peeling of inside enamels.

Thermal Exhausting

When cans must be exhausted in steam, it is imperative that the exhaust box temperature be held above 205°F. When exhausting temperatures are below 205° F, considerable air is mixed with the steam, and under such conditions some rusting is apt to occur.

In hot water exhaust boxes the temperature should be as near the boiling point as possible. In addition, care must be taken to avoid aeration of the water and accumulation of corrosive agents due to product spillage and concentration through evaporation. Thermal exhausting equipment must be kept clean and free from rust.

Code Marking

Can covers are usually coded mechanically by an embossing device driven by the closing machine. Excessive depth of impression, worn or damaged type, too sharp a profile in the marking dies or misalignment of the type used in the marking device will produce sharp imprints which permit external rusting or rapid corrosion on the inside of the can due to fracture of the tin or enamel coating. Closing machine operators should be instructed to secure type without excessively sharp edges, to determine that they are held in exact alignment in the marking device and to maintain the marking pressure just as light as possible to avoid fracture of the inside enamel and still obtain legible imprint.

The use of ink marking devices avoids such difficulties and this method of coding is recommended for cans packed with acid products. Ink marking also is used for aluminum cans with easy-opening ends since it is impractical to emboss the special ends. Ink with a phenolic base should be avoided to preclude the possibility of product off-flavors.

Faulty Closures

Improperly formed top double seams may permit leakage and spoilage, producing external rusting on adjacent cans. With fruits and other acid products extensive rusting may occur if leaky cans are not promptly discovered and removed from the stacks. Regardless of tin coating weight, liquid from one leaky can may rapidly perforate adjacent cans from the outside and the process will continue until there has been a heavy loss.

Faulty closures may also accelerate internal corrosion by permitting air to enter the can. In addition to producing early hydrogen swells, air leakage may cause perforations with the consequences outlined above.

Frequent periodic inspection of filled cans is facilitated by palletized storage of the cans in narrow blocks, permitting visual examination of the maximum number of cases for evidence of leakage.

Washing the Sealed Cans

Even with well controlled filling and syruping operations some spillage of salt brine or acid sugar syrup is to be espected. Allowed to remain on the can, the residues resulting from spillage will induce corrosion and rust formation.

To avoid trouble from this source, the sealed cans should be washed as they leave the closing machine with water sprays delivered under good pressure. Spray washers can be set in the line in the closing machine discharge. The use of hot water in the spray is preferable for effective cleaning. It is essential with those products where a hot fill alone is depended upon for sterilization or where a high initial temperature at the start of the process is a requirement of the heat treatment.

Some canners of products which require only a boiling water process depend upon the processing water to wash the outside of the cans. This is not good practice because continuous delivery of unwashed cans to the processing water builds up a concentration of acid, sugar or salt in the water to the point where residues remain on the surfaces of the cans after they are taken from the processing bath. Even after thorough drying, such residues have a tendency to absorb moisture from the air and thereby promote rusting. Whether the cans are processed in steam or boiling water, the exterior surfaces should be thoroughly washed before retorting.

Meat and fish canneries wash cans after closing to remove residues of grease which accumulate on the outside of the cans during filling and closing operations. Hot alkaline detergent solutions are generally used for this purpose. It is most important to use the minimum concentration of detergent and control it carefully lest it attack the tin coating or outside enamel. If, in spite of these precautions, signs of attack appear, the supplier should be consulted for alternative materials. The cans should always be rinsed with fresh water following the alkaline detergent wash. Highly alkaline detergents should not be used for cleaning aluminum cans since alkalies react readily with aluminum.

Open Water-Bath Operation

Temperature is the principal factor determining the rusting tendency in water-bath processing. The oxygen of the air is soluble in water; increasing temperatures reduce rusting by lowering oxygen solubility. On the other hand, for the same oxygen content, higher temperatures will produce more rust. The net effect of these two conflicting tendencies is to produce the greatest rust hazard at about 175°F.; from here to the boiling point the rusting tendency gradually decreases.

Rusting in boiling water processing can be minimized by being sure that the water is actually boiling at the time the cans are introduced and not "rolling". "Rolling" can be caused by the injection of steam into the water and, while it resembles boiling, occurs at temperatures considerably below the boiling point. The oxygen content of "rolling" water may be comparatively high.

Chemical treatment of the water may be necessary when using water processes, particularly when the processing temperature is below the boiling point. Air agitation of water cooks at temperatures below the boiling point should not be used because it will saturate the water with oxygen and aggravate rust formation.

Steam Retort Operation

In processing cans, strict attention must be given to the details of correct retort operation. "Retort rusting" is promoted by the following improper practices in steam retort operations:

1. Inadequate venting and bleeding of the retorts.
2. A low-pressure steam supply.
3. Excessively long coming-up time.

Conditions established by any of these practices tend to expose the cans to a combination of air, moisture, and high temperature conducive to corrosion and rust formation.

Corrosion caused by improper retort operation is generally characterized by rust development at points of greatest draw or mechanical strain in the plate. Dark red rust usually appears first on the top and bottom double seams. In more severe cases it will form on the can end profiles and embossed code marks.

In general, the suggestions for retort operation provided by the latest edition of National Canners Association Bulletin 26-L, should be observed.

To remove air rapidly from the retort at the beginning of the process, retort vents should be left wide open for the temperature and time prescribed by the Bulletin for the particular type of equipment. Automatic controllers may be by-passed if necessary to prevent an excessive coming-up time. Leave one or more bleed valves open during the entire process to assist in eliminating small residues of air that may be trapped in the retort. Venting of automatic loading systems should be closely checked. Occasionally steam may contain excessive amounts of oxygen or carbon dioxide which will attack the can under the conditions of heat and moisture in the steam retort. This can be avoided by the installation of suitable deaerators and preheaters for the boiler feed water.

Special precautions are required in processing aluminum cans. Separator sheets should be placed between layers in the retort basket. The separators should not be made of a dissimilar metal since galvanic actions between the metals could cause corrosion of the aluminum cans, particularly at the scored area of an easy-opening end. Aluminum cans with easy- open ends should always be pressure cooled after processing to avoid undue strain on the scored ends.

Contact with Rusty Iron

A condition somewhat related to rust is sometimes caused during sterilization by contact with rusted retort crates or trays. The discolored condition is termed "steam burning" and is evidenced by a typical multi-colored iridescent film on the can found only at points where it contacts the rusty iron. No discoloration occurs where the iron is clean and unrusted. If this problem is encountered, the rusted areas of the retort crates or trays should be covered with an inert material. Avoid closing any of the openings in the crates or trays as this could retard steam circulation in the retort.

Contact with Alkaline Water

Alkaline water may produce unsightly etching and spangling of the can. Prolonged exposure results in an attack on the tin coating or outside enamel, leaving the cans readily subject to rusting. Alkaline water can also cause severe corrosion of aluminum containers, particularly at score lines.

Alkalinity of the water may result from alkaline detergents carried to the retort on cans, from carry- over of alkaline salts from the broiler, or from the concentration of naturally alkaline water in the retort. Corrective treatment may be applied to each condition and if corrosion of this nature occurs, advice should be sought from a competent laboratory. In any event, it is good practice to blow the condensate from the bottom of the retort through the drain a few minutes after reaching processing temperature.

Improper Cooling

When water cooling is employed, the contents of cans should be cooled to 95° - 105° F. average temperature, this being defined as the temperature obtained after thoroughly mixing the contents of the cans by shaking. If the cans are cooled to an average temperature appreciably below 95°F., the heat retained in the cans is insufficient to evaporate the residual moisture on the can surfaces and rusting may occur. On the other hand, if the average temperature after water cooling is greater than 105° F, there is danger of flat sour spoilage, early hydrogen springer formation, or quality degradation, depending upon the nature of the product.

Elimination of residual water by evaporation must be supplemented by mechanical removal. This may be accomplished by tipping the retort crates after they come from the cooling tank, by removing the cans from the crates and stacking them on their sides, or by use of one of several types of can drying systems.

The practice of taking cooled cans from the retort crates without draining, or with only superficial draining, and packing directly into cases must be avoided.

Corrosive Water Supplies

The chemical composition of the water used in processing and cooling may be a factor in the production of rust. The danger of accumulation of alkaline residues or the carry-over of alkaline substances from the boiler into the processing water has been referred to above. Waters of high natural alkalinity will attack metal surfaces during boiling water processing or pressure processing carried on under water. The action of these waters will etch or spangle the cans, and, in addition to this undesirable discoloration, will leave them more easily subject to rusting during storage . If the offending water contains appreciable concentrations of chlorides, sulphides, or sulphates, the can may be attacked with formation of rust and discoloration during the process.

In similar manner, alkaline waters, excessively chlorinated waters, waters high in chlorides or sulphates, and slightly acid waters may induce corrosion when used for cooling purposes. Factors which influence the degree of this type of attack, other than the condition of the water itself, are the time of cooling and the temperature of the water. Following the general rule for chemical reactions, the attack by corrosive waters is accentuated as the temperature rises. In addition, when the cooling water is warm the cans must be exposed to the water fot longer periods of time to effect the necessary cooling.

In general, the problems associated with the use of alkaline or corrosive waters require specific remedial treatments for each water supply. Accordingly, if there is any indication that the water supply may be involved in a rusting problem, a laboratory associated with the industry should be consulted.

Scratches and Abrasions

Scratching or abrasion of the tin coating on cans exposes the steel base metal, with consequent danger of rusting, the coating of the can may be marred or scratched by rough handling of either empty or filled cans. Operators must be cautioned to exercise care in loading cans onto runways, in transferring them to retort trays or baskets, and in the casing operation. Runways, gravity drops, elevators, exhaust boxes and can dividers must be carefully inspected to eliminate points where scratching, abrasion, or denting can occur.

Particular care is required in handling aluminum cans with easy-opening ends. The easy-opening feature which provides easy access to the contents for the consumer also reduces resistance to abusive handling. Modifications of equipment may be necessary to avoid all rough handling. Filled cans should be cased with a separator sheet between layers to avoid damage to the easy-open end by flexing action on the opening tab.

CORROSION ATTRIBUTABLE TO STORAGE CONDITIONS

High Storage Temperature

Perhaps the greatest enemy of long service in metal cans is high storage temperatures. Prolonged exposure to temperatures above 75°F. will result in early development of hydrogen swells and perforations, regardless of the weight of tin coating on the cans. Under abnormally severe conditions losses may occur even in foods usually considered non-corrosive.

It is imperative that adequate attention be given to the maintenance of reasonable warehouse temperatures. Special emphasis must be given to the temperature of the cans at the time of casing, and also to the method of stacking the cases in the warehouse. Palletized storage or stacking in narrow blocks permits ventilation, which soon reduces the temperature of the cans to that of the warehouse.

Sweating

Moisture on the surface of the can will lead to rust formation during storage. One of the most frequent causes of external rusting during storage or shipment is the process of sweating.

Sweating will not occur if the temperature of the cans is equal to or greater than that of the surrounding atmosphere. If the temperature of the cans is less than that of the atmosphere, sweating may occur, depending upon the magnitude of the temperature difference, and also upon the relative humidity. The conditions most likely to cause sweating are high relative humidity and a can temperature well below that of the air.

Theoretically, the best storage condition from the standpoint of rust prevention would prevail if the cans were maintained always at a temperature somewhat higher than that of the surrounding atmosphere. This is not practicable, of course, and from the commercial standpoint the best conditions are established when the cans are maintained at the same temperature as the surrounding atmosphere. This may be accomplished by proper heating and ventilating of the storage quarters. The warehouse temperatures and relative humidities should be measured frequently.

Most sweating develops when sudden increases in the temperature and humidity of the atmosphere occur. In most areas this condition is met in the Spring when warehouses are likely to be cool. If a cool warehouse is opened to the outside air on a warm, humid day following a cool period, some sweating is almost certain to occur, particularly on uncased cans near the outside of the stack. When such atmospheric conditions occur, the warehouse doors should be kept tightly closed until the temperature of the cans is brought up to that of the outside air, or slightly higher. Any planned change in warehouse temperature should be made gradually. Sweating may also occur during shipment of cold cans into warmer areas.

The introduction of steam into the warehouse from brine tanks, boiling water baths, retorts, or other sources will increase the relative humidity and may also effect the temperature of the atmosphere. For these reasons, warehouses should be so located and so protected as to prevent the access of steam.

Other Causes of Rusting

Cans stored in warehouses located near seacoasts or transported by ship are particularly subject to external rusting because of the corrosive action of salt spray. To protect the cans from salt and high humidity in the air, it is advisable to store them in tight cases. Coastal warehouses should be so constructed and ventilated that a minimum of air currents from the ocean enter the storage areas.

Rust may occur in fibre cases if the fiberboard is damp. Green lumber with comparatively high moisture content may produce rust when used for cases or pallets. Special care must be taken to avoid casing wet cans in moisture- resistant cartons from which evaporation is very slow. Rusting has occurred with fiberboard having a high salt content. An unsuitable carton adhesive can also lead to rust formation.

Some instances of staining and rusting have been attributed to the hygroscopic nature, i.e., moisture- absorbing property, of certain label pastes. The packer should receive assurance from the manufacturer that the paste and glues used in his labeling operations are satisfactory from this standpoint. It is possible for the label papers to accelerate rusting; some are more hygroscopic than others and may contain rust producing substances.

Rusting of cans may also result from exposure to such corrosive atmospheres as vinegar fumes in pickle plants. Sulphur dioxide in the atmosphere, which can result from the storage of brined cherries and similar products in the same warehouse as canned goods, will also produce rusting.

CAN ENAMELS (LININGS, COATINGS)

Organic coatings are useful on cans for canned foods to prevent chemical interactions between the food and the container when these reactions may adversely affect canned food quality. Although many attempts have been made to develop an all-purpose protective coating, they have not been successful. Some 20 different enamels are needed to meet the requirements of the many products now packed in cans. Plain (uncoated) cans are used when the can-food interactions are not significant, or when the quality of the food is better in a plain can. The plain tin causes a bleaching action and improves the color of some products which normally would darken in a fully enameled can.

Types of Enamels

Oleoresinous These are the most common types. They include the "R" or fruit enamels, and the "C" enamel.

The "R" enamel is used especially to protect the natural pigment of highly colored fruits, such as dark colored berries and cherries, and also beets.

The "C" enamel is used to prevent "black sulfide" discoloration in foods such as corn, peas, poultry, and seafoods. "C" enamels contain about 15% zinc oxide in suspension, added for its chemical reactivity and not as a pigment. The sulfides that form during processing or heat sterilization in protein-containing foods high in sulfur- containing amino acids react with the zinc oxide to form white or essentially colorless zinc compounds. Can linings containing zinc oxide were first developed for corn and were called "corn enamels"; their use was soom extended to other foods, and they were then called "C" enamels.

Oleoresinous enamels are formulated to have good barrier resistance between acid products and the metal of the cans.

Phenolic. These are used for seafoods, certain meat products, pet food, and other products. They have greater impermeability and chemical resistance than the oleoresinous types, but are also characterized by minimum flexibility and a tendency to impart flavor and odor to some foods. They do not require ZnO for sulfide stain resistance and they are not softened by animal fats.

Epoxy. These are characterized by high heat stability as shown by their lack of discoloration in the soldering of side seams of the can. They have excellent flexibility as shown in forming and seaming operations on ends, and freedom from flavor second only to the vinyl type. Epoxy enamels may be modified with phenolic and used for fruits and high-fat content foods.

Vinyl. These enamels are usually used as a double coating in combination with an oleoresinous or a phenolic enamel. They are commonly used for the more highly corrosive foods. A typical example is a system having a basic coat of "R" enamel, and a top coat of vinyl with side seam striping used for apple juice. Side seam striping consists of an additional coating striped on the inside of the can side seam. Vinyl enamels are tough and free from flavor. They have poor resistance to steam but are well suited for products sterilized at 200°F or less.

Other enamels are the *epoxy-modified vinyl* used for highly colored fruits over a phenolic- modified epoxy; the modified *phenolic,* which when aluminum pigmented is used for meats; the *expoxy-ureaformaldehyde;* and the *alkyds.*

Desired Qualities of Enamels

Enamels for food cans should have the following characteristics: (a) lack of toxicity; (b) should not affect the flavor or color of food; c) should be an effective barrier between food and container; (d) should be easy to apply on tin plate; (e) should not peel-off or blister during canned foods sterilization and storage; (f) should have mechanical resistance to can manufacturing operations; and (g) should be economical.

Trends

For many years there has been a trend to decrease the thickness of the tin coating on the steel plate for economic and strategic reasons. Better enamels, improvements in steel metallurgy, and the development and improvements of electrolytic tin plating have resulted in continually improved performance of tin plate cans for canned foods.

Evaluation of Enamels

In the development and evaluation of an inside enamel for cans, flavor testing justifiably receives great attention. The flavor of every product is affected to some extent by the container whether it be made of glass, metal, or flexible packaging material. After a time, consumers become more or less accustomed to the flavor which may be associated with a specific type of container and may reject as unsatisfactory many other containers. As an illustration, enamel linings have been accused of imparting an "enamel flavor" to some products normally packed in plain tin cans. Generally, tomato juice packed in plain cans is preferred from the standpoint of flavor to the same juice packed in enamel cans. By coincidence, it appears that this preference of the tomato juice from the plain can is related to the presence of small amounts of tin dissolved from the container, or perhaps to the reducing action of the plain tin surface on the tomato juice.

When tin is exposed to some food products a bleaching action occurs. Although this is very objectionable with many products, such as the red fruits, and is avoided by the use of a suitable can lining, there are instances when this bleaching action is desirable. This is particularly true with the lighter colored products such as grapefruit juice and grapefruit segments and sauerkraut. The slight bleaching action keeps the color light and compensates for the normal darkening effect which may result from the processing or sterilization. Peaches and pears packed in cans completely enameled inside will be somewhat darker in color and slightly different in flavor than if packed in cans lined with plain tin. Although some individuals may prefer peaches packed in all enameled cans, it is doubtful if such cans will be produced under present conditions because the presence of an appreciable area of plain tin greatly increases the shelf life of this canned product.

Under current manufacturing conditions an all-enameled can will have all but a few very small areas covered with the enamel. Corrosion attended by the formation of sufficient hydrogen to displace the vacuum normally found in packed food cans and actually causing the ends to "swell," may occur in much less time in enameled cans than in "plain" or partly plain cans. In some cases the corrosion may be so confined to localized areas that the can may be perforated by one or more "pinholes." Contrary to some lines of reasoning, not all corrosion problems can be eliminated by the use of can linings as now available.

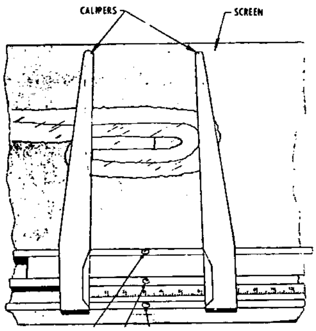
CAN SEAM INSPECTION

The can manufacturing companies usually give advice and help set up can seam inspection programs in canning plants. Can manufacturers also have available excellent bulletins describing with the aid of illustrations the can seam inspection procedure. Following is a discussion of the main factors related to can seam inspection.

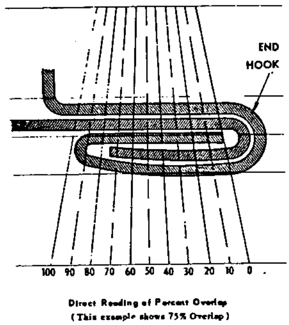
Visual Examination of Double Seams

During regular production runs, it is essential that a constant watch be maintained in order to catch gross maladjustments such as deadheads, cutovers, and other similar double seam defects. Maintaining this constant check may be accomplished in several ways, depending on the type of machine, line speeds, and general equipment layout. It may best be performed by the closing machine operator trained to recognize irregularities by visual examination. However, an equally adequate check program can be maintained through use of other trained personnel.

The operator or can closure supervisor should visually examine, at intervals of not more than 30 minutes, the top seam of a randomly selected can from each seaming station, and should record his observations. Additional visual seam inspections should be made immediately after a can-jam in a closing machine; or after start-up of a machine following a prolonged shut-down. All pertinent observations should be recorded. If irregularities are found, the action taken should be noted.



Exact measurement of hook lengths is of real importance. Most companies have established minimum limits. Hook lengths, therefore, are measured in 1,000ths of an inch, without guessing.



Butting and exact overlap percentages are read directly without computations on the Nomograph Card.

The Seam Projector produces a magnified image of the cross-section of can seams. Automatic focusing and independence from factory lighting conditions make it an accurate and practical production control tool for the plant.
(Courtesy Wilkens-Anderson Company)

Tear-Down Examination of Can Seams

The minimum frequency recommended for making tear-down examinations is one can per seaming station taken at intervals not to exceed 4 hours. It should be made as soon as possible after starting up following a shut-down, waiting only long enough for the machine to "warm up." Cans for visual inspection should be taken during this warm up period. The results of the tear-down examinations should be recorded, and corrective actions, if any, should be noted.

General Observations

Following are some of the various factors which influence double seam quality:

1. Condition of the seaming equipment—whether or not the mechanical operation and adjustment of the closing machine give the proper seam contours.

2. Can material—variations in tinplate thickness.

3. Can size—roll contours change with can size to accommodate variations in plate thickness.

Other pertinent observations should also be recorded indicating the presence or absence of such defects as cutover, droops, etc.

Essential and Optional Seam Measurements

Optical System (use of seam scope or projector) Essential—body hook; Overlap; Tightness (observation for wrinkle).

Optional—Width(length,height); Cover hook; Countersink; Thickness

Micrometer Measurement System

Essential—Cover hook; Body hook; Width (length, height); Tightness (observation for wrinkle). Optional—Overlap (by calculation); Countersink; Thickness.

Regardless of whether or not a seam scope or seam projector is used, the double seam should be torn down for examination.

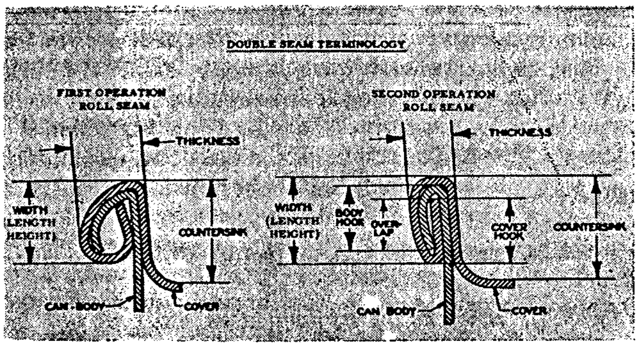
It is standard procedure to make two measurements for each double seam characteristic if a seam scope or seam projector is used. If a micrometer is used, three measurements are made at points approximately 120° apart excluding the side seam. The high and low measurements must fall within limits considered to be normal for the conditions.

With regard to measurement limits, the canner should follow the working limits recommended by the can supplier.

Overlap length can be calculated by the following formula: the theoretical overlap length=CH+BH+T−W. CH= cover hook; BH= body hook; T = cover thickness, and W = seam width (height, length). In general practice, 0.010 in. may be used for the tinplate thickness.

With regard to record keeping on seam examinations, the form of the records shall be the choice of the canning company, but the records must show the frequency of visual and tear-down inspections, and what measurements were made. It is suggested that sample forms be obtained from can suppliers.

The following diagram of a double seam shows the measurements to be made and the terminology for the measurements. A diagram such as this one should be displayed in the plant area where seams are to be examined.



HOW TO TEAR DOWN SEAMS

The older method of inspecting a double seam which still prevails to a certain extent was to file or saw a notch through it so that the construction of the seam could partially be seen through a magnifying glass. This method of inspection was found inadequate, in that the cover and body hooks could not be accurately measured and inspected, nor could it be determined whether or not the seam was rolled tightly enough. This led to the general accepted method of stripping the seams which permits accurate measurements of the hooks and a good visual inspection of the cover hook to see that the wrinkles are sufficiently ironed out to assure a tight seam.

Some packers strip the entire seam, while others find it more advantageous and preferable to leave from an inch to an inch and a half of the double seam opposite the side seam undisturbed. In this latter case, the cover is left hinged to that portion of the double seam that will not be stripped off. This method of stripping in the canneries has the following advantages:

a. The coded top and the cover hook portion of the seam stay affixed to the can and will not become separated or lost. This assures accurate identification of the entire can which can be inspected by the serviceman or the interested cannery personnel.

b. It permits measurement of both hooks at up to 4 points at 90° apart, or at 3 points at 120° apart, either of which is considered satisfactory.

c. Permits a good visual inspection of the cover hook.

d. Permits outside inspection and measurement of the undisturbed portion of the double seam.

e. Permits filing a notch through the undisturbed portion of the double seam to see if can and cover hook are properly abutted.

Adequacy of Double Seams and Recognition of Defects

It will be appreciated that there are mechanical differences in various manufacturer's closing machines. These closing machines all produce good strong double seams when properly set up and adjusted. However, one manufacturer's double seam construction may vary slightly from another. It is very difficult, if not impossible, to give one set of double seam specifications that would apply in all cases and for all sizes of cans. For that reason, it is recommended that each packer's closing machine operators and other interested personnel, obtain detailed double seam information from the serviceman who calls at their plants.

There are, however, the following fundamental characteristics of a double seam that, if followed, will result in a good strong seam on any standard closing machine.

A–There should be no "cut overs" which may cause cans to leak. (Caused by tin being rolled over the chuck.)

B–Double seams should not be rolled so tightly that they become distorted and stretched. An otherwise good double seam can easily be ruined by rolling it too tightly.

C–A good seam is one in which the first operation has been rolled just tightly enough to produce the desired length of cover hooks and the second operation tightly enough to iron out the wrinkles in the cover hook without stretching the tin.

Four classifications of wrinkles:

0–No wrinkles to a slight trace of a wrinkle. (Good double seam if not rolled too tightly.)

1 -Slight wrinkle, up to about 1/3 the depth of the cover hook. (Questionable tightness for top double seams)

2–Somewhat heavier wrinkle, more pronounced and–extending approximately 1/2 the depth of the hook. (Seam is dangerously loose and should be tightened before further operation.)

3–Larger wrinkle, extending down about 2/3 the depth of the hook. Cover hook slightly rounded. (Seam will leak–it is definitely too loose to be used.)

D—Can and cover hooks each to be about the same length, and to be kept within a tolerance range of from .074 to .084 inches in length. The best results will be obtained by maintaining a hook length half way between these limits. (These dimensions refer to cans with diameters ranging from 301 to 404 inclusive.)

E—Countersink depth from the top of the seam to the cover should be approximately .125 or 1/8", depending in some cases, on size ranges of cans.

The general appearance of the cans should also be noted—especially if there is anything abnormal. Canners become so familiar with normal cans of food that any abnormal feature will be quickly noticed. A complete description of the abnormal cans should be recorded so that the cause of the trouble may be determined and steps taken to overcome it.

MISCELLANEOUS INFORMATION ON TINPLATE CANS

Following are three tables that are useful for calculating data related to can handling and shipping.

TRADE NAMES OF SOME OF THE MORE COMMON CAN SIZES

Can size	Trade name
202 x 204	2Z Mushroom
202 x 214	5Z Baby Food
202 x 308	5Z Jitney
202 x 314	6-1/2Z
211 x 200	211 Baby Food
211 x 212	4Z Mushroom
211 x 300	8Z Short
211 x 304	8Z Tall
211 x 400	No. 1 Picnic
211 x 414	211 Cylinder
300 x 206	7Z Pimientoes
300 x 400	8Z Mushrooms
300 x 407	No. 300
301 x 411	No. 1 Tall
303 x 406	No. 303
307 x 400	No. 95
307 x 409	No. 2
307 x 510	Jumbo
307 x 704	Quart Olive
307 x 710	32Z (Quart)
401 x 206	No. 1-1/4 (Veg.)
401 x 411	No. 2-1/2
404 x 307	No. 3 Vac.
404 x 414	No. 3
404 x 700	No. 3 Cyl (46Z)
502 x 510	No. 5
603 x 408	No. 5 Squat
603 x 700	No. 10
603 x 812	No. 12 (Gal.)

EQUIVALENT, IN CASES OF 24/2's, OF THE MORE COMMONLY USED CANS

Case of 48 8Z short	=	0.77 cases 24 No. 2's
Case of 48 8Z tall	=	0.84 cases 24 No. 2's
Case of 48 No. 1 (Picnic)	=	1.06 cases 24 No. 2's
Case of 24 No. 300	=	0.74 cases 24 No. 2's
Case of 24 No. 303	=	0.82 cases 24 No. 2's
Case of 24 No. 2-1/2	=	1.45 cases 24 No. 2's
Case of 24 No. 3	=	1.71 cases 24 No. 2's
Case of 6 No. 10	=	1.33 cases 24 No. 2's

The capacity of a 16-oz glass jar is approximately the same as the No. 303 tin can.

The capacity of a No. 2-1/2 glass jar is approximately the same as the No. 2-1/2 tin can.

CAPACITY AND CONVERSION FACTORS OF CANS MOST COMMONLY USED IN CANNING FRUITS AND VEGETABLES

Name	Dimensions	Total Capacity, Avoir. Oz. of Water at 68°F	No. 2 Can Equivalent
6Z	202 x 308	6.08	0.295
8Z Short	211 x 300	7.93	0.386
8Z Tall	211 x 304	8.68	0.422
No. 1 (Picnic)	211 x 400	10.94	0.532
No. 211 Cylinder	211 x 414	13.56	0.660
No. 300	300 x 407	15.22	0.741
No. 300 Cylinder	300 x 509	19.4	0.945
No. 1 Tall	301 x 411	16.70	0.813
No. 303	303 x 406	16.88	0.821
No. 303 Cylinder	303 x 509	21.86	1.060
No. 2 Vacuum	307 x 306	14.71	0.716
No. 2	307 x 409	20.55	1.000
Jumbo	307 x 510	25.8	1.2537
No. 2 Cylinder	307 x 512	26.4	1.284
No. 1-1/4	401 x 206	13.81	0.672
No. 2-1/2	401 x 411	29.79	1.450
No. 3 Vacuum	404 x 307	23.9	1.162
No. 3 Cylinder	404 x 700	51.7	2.515
No. 5	502 x 510	59.1	2.8744
No. 10	603 x 700	109.43	5.325

In the above table the "No. 2 Can Equivalent" indicates the number of No. 2 cans equal to each of the cans designated in column 1. The No. 2 case equivalent may be obtained by dividing the number of cans per case of the can to be converted by 24, except for No. 10 Cans where the factor is 6, and multiplying the result by the "No. 2 Can Equivalent".

TIN PLATE BASIS WEIGHTS

The base box is the unit of area of 112 sheets, 14 in. x 20 in. or 31,360 sq. in. (217.78 sq. ft.) Basis weights, which determine the approximate thickness of the plates, are customarily expressed in pounds per base box.

Weight		Thickness	Weight		Thickness
Lb/Base Box (Basis Weight)	Lb/Sq Ft	Inches	Lb/Base Box (Basis Weight)	Lb/sq Ft.	Inches
45	0.2066	0.0050	148	0.6796	0.0163
50	0.2296	0.0055	155	0.7117	0.0171
55	0.2525	0.0061	168	0.7714	0.0185
60	0.2755	0.0066	175	0.8036	0.0193
65	0.2985	0.0072	180	0.8265	0.0198
70	0.3214	0.0077	188	0.8633	0.0207
75	0.3444	0.0083	195	0.8954	0.0215
80	0.3673	0.0088	208	0.9551	0.0229
85	0.3903	0.0094	210	0.9643	0.0231
90	0.4133	0.0099	215	0.9872	0.0237
95	0.4362	0.0105	228	1.0469	0.0251
100	0.4592	0.0110	235	1.0791	0.0259
107	0.4913	0.0118	240	1.1020	0.0264
112	0.5143	0.0123	248	1.1388	0.0273
118	0.5418	0.0130	255	1.1709	0.0281
128	0.5877	0.0141	268	1.2306	0.0295
135	0.6199	0.0149	270	1.2398	0.0297
139	0.6383	0.0153	275	1.2627	0.0303

Tin plate is also produced for special uses in weight other than those shown in the above table.

Warehousing of Empty Cans

The warehouse must be protected from dampness and steam, and it should be at such an elevation over the filling machines or filling tables that properly constructed chutes will deliver the cans by gravity to points where they are filled. When storing cans in bulk in bins, lay on side in even and regular tiers. When storing in shipping cases, place the bottom layer end up.

ALUMINUM CANS

In 1973, the amount of aluminum used for fabricating cans reached 1,307 million pounds, a large percentage of the cans was used by the beverage and food industries.

Increasingly greater attention is being given to aluminum for fabricating cans and other containers for processed foods. Its use to date has been mainly in applications where there is some inherent advantage over the use of tinplate such as lower shipping expense, freedom from food and can black sulphide discoloration or rust, easier puncture opening, and where special easy opening features are desirable.

Tinplate cans are so well established in the canning industry that exceptionally good reasons are required before a change of material is contemplated. The present and future use of aluminum for cans, particularly in the large market for processed food use, is to a great extent dependent on the price at which it may be sold to the users, relative to that of an equivalent tinplate can.

On the other hand, while aluminum might be more costly per unit area than tinplate, it would be wrong to draw the conclusion that aluminum cans are in no position to compete with tinplate cans. The materials are sufficiently different in their properties for tinplate to do well under conditions that are not conducive to the use of aluminum, and for aluminum to replace tinplate when aluminum shows advantage. When all applicable factors are considered, there are instances where aluminum cans offer advantages of product quality, economy, and national strategic value for the canning of certain food products. The use of easy-open lids is also a significant point which has a strong appeal. Even if an opener is not available, the aluminum can may be quickly and safely opened with a knife. Aluminum cans do not rust. Their appearance, always bright, can be an important sales argument.

Two-piece aluminum cans have been available for more than a decade. Two-piece metal containers offer several advantages over their three-piece counterparts. Leakage possibilities are greatly reduced as a result of eliminating two seams; instead of three seams - top and bottom double seams and side seam - there is only one, the top double seam. Production problems appear to be likewise reduced in making the two piece can and the equipment manufacturers claim that less experienced personnel can operate the two-piece line. Two-piece cans use less metal as there is no overlap for the side seam and bottom double seam. This not only reduces cost but permits making a greater number of cans from a given quantity of scarce metal. Bottom configurations can be designed for improved stackability on grocery shelves. And most of all, aluminum cans are recyclable, which conserves valuable natural resources and helps with out litter and solid waste disposal problems.

Production of the two-piece can is either by a drawn and ironed or a draw and re-draw operation. With either method, the first steps are the same. A disc is stamped from a sheet or ribbon of metal. The disc is then drawn into a cup by use of a hydraulic ram and die. The last steps of the operations are likewise identical. After the can body is formed, the top is trimmed, a flange is produced on the top, body is beaded, and finish treatment applied. Some cans are available with a necked-in configuration. The two methods differ primarily in how the can body is formed from the cup. With the drawn and ironed method, the cup is forced by a ram through a series of dies, each slightly smaller than the preceeding one, which elongates the side of the body by stretching out - ironing - the side and in the process, reducing the thickness of the metal. With the draw and re-draw method, the cup is likewise forced through dies by a hydraulic ram, but in the process, the circumference of the container is reduced with the excess metal being used to elongate the side wall and with no change in thickness of the metal.

Plant Handling of Aluminum Cans

Outside enameled ends are required to facilitate handling in the cannery and to reduce the buildup of aluminum fines in the canning lines. To effect smooth transfer of aluminum cans, many pieces of equipment must be hard chrome plated. In some instances, the installation of Teflon-covered conveying systems is advantageous. All equipment parts using a magnetic principle must, of course, be replaced for handling aluminum cans.

In the more general application of aluminum to processed vegetables, fruits, fish, and meats, consideration must be given to providing a can strong enough to withstand the handling and mechanical stresses imposed during processing and distribution. Aluminum producers are striving to formulate an alloy with physical properties such that it can be substituted for tinplate on a gauge for gauge basis. However, the higher strength alloys employed still require an increase of about 35% in the gauge of aluminum to provide equivalent buckling resistance to conventional tinplate in 303 diameter cans. An increase in gauge of approximately 50% over that of nitrogenized double cold reduced tinplate is required.

The extent to which heavier gauges of aluminum will be required to provide cans that are as rugged as tinplate probably holds the key as to whether aluminum will be used in the near future for the large volume processed vegetable and fruit products. Another possibility is that of modifying the processing and can handling operations to accommodate less rugged cans. It is difficult to estimate what the effect of such changes upon production costs might be, but definite increases would be expected under present conditions.

For some foods in smaller can sizes, modifications of the canning procedure have permitted the use of less rugged cans than are currently employed. As an example, to avoid the buckling or straining of the ends, pressure cooling could be used after sterilizing in autoclave. However, there must be a delicate balance between the pressure required to maintain flat ends and that which would cause paneling of bodies as the cans are cooled. For some products superimposed pressure during the entire sterilizing process may be required.

In addition to considering the practicability of aluminum cans in terms of their initial cost and to forecast what would need to be changed in a packer's operation to accommodate aluminum cans, it is necessary to know what the shelf-life of the products will be in aluminum containers. This revolves around the inherent corrosion resistance of the container and the chemical activity of the product, matters which cannot always be altered by engineering nor accomplished at tolerable increases in costs, even though the economics and engineering pictures of aluminum cans have been changing rapidly and making aluminum more competitive as a food packaging material.

Corrosion Resistance

As a household metal and in food processing operations, aluminum is considered a corrosion-resistant metal. Experimental and practical experience in food canning has shown that most beverages and foods in uncoated aluminum cans react with the metal quite readily. The addition of alloying elements to pure aluminum influences its corrosion resistance properties, imparts strength and improves formability characteristics. In general, these alloys have good corrosion resistance with most foods and beverages. However, almost without exception, processed foods, as well as juices, soft drinks and alcoholic beverages, require containers with inside enamels to maintain an acceptable shelf life. A table shows various types of organic coatings (enamels) used in the interior of aluminum cans and ends.

INTERNAL COATINGS USED ON ALUMINUM CANS AND ENDS

Product	Can Body	Can End
Beer	Vinyl Epoxy	Vinyl Epoxy
Soft Drinks	Vinyl Epoxy	Solution Vinyl
Sardines	Epoxy Phenolic	Epoxy Phenolic
Potted Meat	Vinyl Phenolic	Vinyl Phenolic
Puddings	Vinyl Phenolic	Vinyl Phenolic

Fruit and Vegetable Canning

The shelf-life of canned fruits and tomato products packed in plain aluminum cans is extremely limited, but is considerably longer in inside enameled cans. Canned vegetables, other than tomatoes, show some differences between plain and enameled aluminum cans. In general, however, most vegetables also require an internal enamel on aluminum cans to obtain a satisfactory shelf-life. It has been reported that canned corn yields an exceptionally high quality product when packed in plain aluminum cans.

Meats and Seafoods

Aluminum cans properly protected against interior corrosion are especially satisfactory for canned meats and seafood products. The problem of black iron-sulfide staining of the container or of the product does not exist with aluminum. However, the tendency of aluminum to bleach some pigments is what causes the pinkish color of shrimp to turn muddy gray and produce also a hydrogen sulfide-like odor. The use of citric acid or lemon juice to lower the pH of the product to 6.0–6.4 reduces these problems significantly. The development of organic coating systems exceptionally effective in blocking the direct contact of aluminum with the product may solve this problem.

Shallow drawn aluminum cans are being used for canned tuna, sardines, crab meat, lobster, and oysters. When crab or lobster is packed in aluminum cans, there is no need to line the cans with parchment paper to avoid discoloration of the product. Sardines prepared in tomato sauce and mustard sauce should not exceed 3% total acidity, expressed as acetic acid. Tomato sauce and mustard sauce are corrosive products that can attack enameled metal containers.

Other processed foods marketed in shallow drawn cans include potted meats, luncheon meats, corn beef hash, boned chicken, chili con carne, chili with beans, and dehydrated soups. Those products as well as Vienna sausages and pet foods are also sold in drawn and redrawn cans with or without easy-open lid.

Carbonated Beverages and Beer

Aluminum cans fabricated by the impact extrusion or the drawing and ironing method are extensively used for pressurized beverages such as beer and soft drinks.

Collapsible Tubes

Aluminum may also be used in the form of collapsible tubes for packaging processed food products. Although aluminum tubes have been used for some non-processed foods, the development of a tube suitable for a sterilized product presented several problems. Industry and federal government laboratories working in cooperation have solved those problems and developed sterilized foods packaged in collapsible tubes for the feeding of astronauts and high altitude aviators.

The aluminum tube fitted with a hollow handled plastic spoon which can be attached to the neck of the tube should make a desirable and convenient package for feeding infants or bedridden patients.

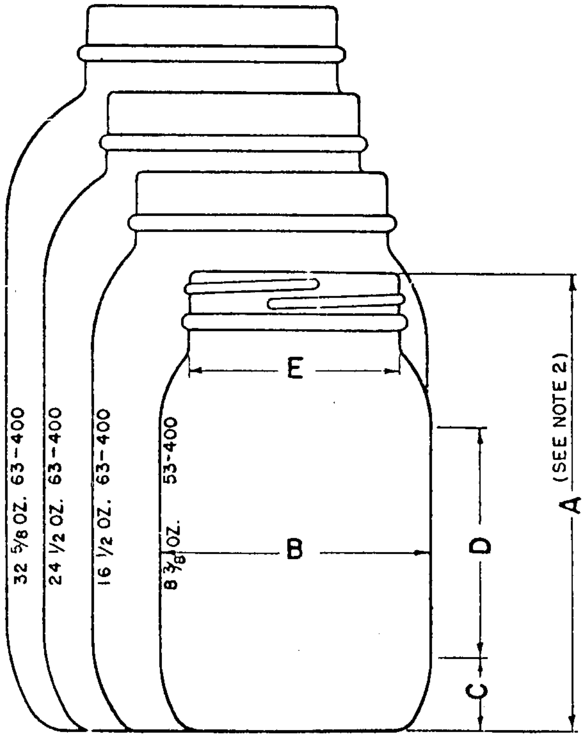
Flexible Packages and Semi-Rigid Containers

Aluminum is widely used in flexible specifications and semi-rigid containers for the protective packaging of a very large number of food products. As a result of extensive development and testing by thermoprocessing and aseptic techniques, the use of flexible, laminated pouches and formed aluminum containers for shelf-stable foods is nearing commercial reality. The increasing use of aluminum for food packaging has been made possible by successfully combining it with specialized plastics, papers, adhesives, and coatings. In many applications, aesthetic as well as protective characteristics are also provided.

The retortable pouch as a package for heat preserved foods offers potential improvements in convenience and quality by virtue of its shape and composition. The pouch is a thin rectangular package. During heat processing, this configuration allows for rapid heat transfer to destroy microorganisms at the innermost part of the package without excessively overheating the product near the pouch wall. At the end of the process, the contents are likewise more rapidly cooled. On the average, there is less exposure to heat which adversely affects certain foods. Consequently, when those foods are processed in the pouch, their inherent properties are less severely degraded and a quality improvement is always observed. Foods processed in pouches are easy to store without refrigeration, and are quickly heated to serving temperatures in three to five minutes as a boil-in-bag.

GLASS CONTAINERS

Following are some diagrams and tables that give the characteristics of some of the more important glass containers used for canned foods.

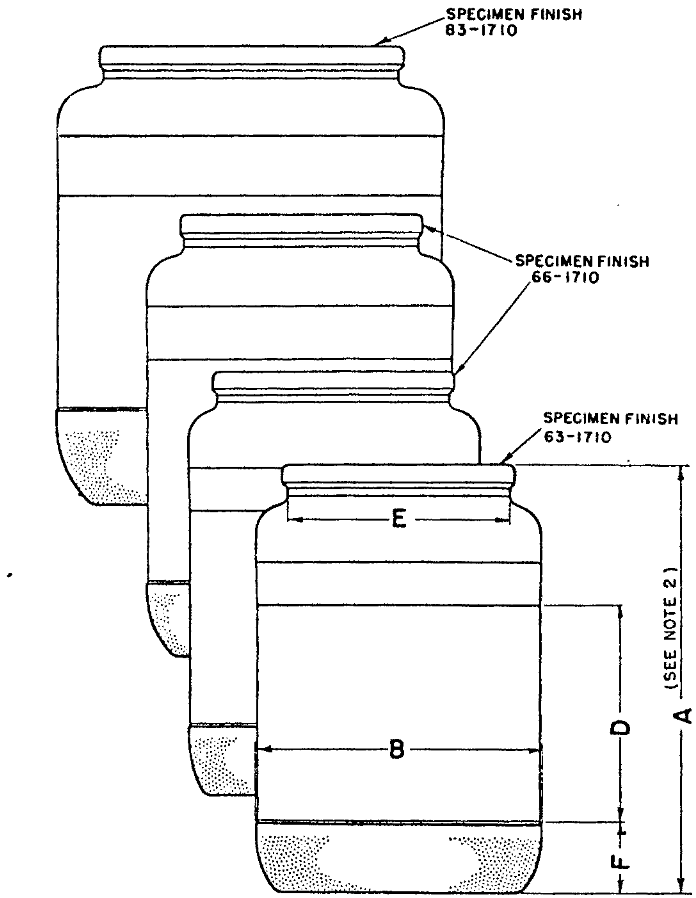


GCMI ITEM NO.	CAP. O'FLOW FL.OZS	WT. MAX. OZS.	A	B MAX.	C	D	E	SPECIMEN FINISH
10-14	4 1/4	3 3/4	3 25/64	2 1/16	35/64	1 49/64	1 3/4	48 - 400
10-20	6 1/4	4 1/4	3 55/64	2 9/32	5/8	2 1/16	1 15/16	53 - 400
10-24	7 3/4	4 1/2	4 1/8	2 25/64	21/32	2 5/16	2 3/32	58 - 400
10-26	8 3/8	4 3/4	4 9/32	2 1/2	11/16	2 9/64	1 15/16	53 - 400
10-27	8 3/8	4 3/4	4 9/32	2 29/64	11/16	2 3/8	2 3/32	58 - 400
10-28	8 3/4	5 1/2	4 11/32	2 1/2	5/8	2 31/64	2 3/32	58 - 400
10-30	9 1/2	5 1/2	4 31/64	2 35/64	41/64	2 9/16	2 3/32	58 - 400
10-36	11 1/2	6	4 25/32	2 3/4	49/64	2 7/16	2 3/32	58 - 400
10-40	12 1/2	6 1/4	4 27/32	2 53/64	49/64	2 1/2	2 3/32	58 - 400
10-48	15 1/2	7	5 1/8	3 1/32	13/16	2 11/16	2 5/16	63 - 400
10-50	16 1/2	7 1/2	5 7/32	3 1/8	27/32	2 47/64	2 3/16	60 - 440
10-51	16 1/2	7 1/2	5 7/32	3 1/8	27/32	2 47/64	2 5/16	63 - 400
10-52	17	7 1/2	5 11/32	3 7/64	27/32	2 55/64	2 5/16	63 - 400
10-53	18 5/16	8 1/4	5 3/8	3 17/64	29/32	2 49/64	2 5/16	63 - 400
10-60	22 3/4	9 1/2	5 7/8	3 29/64	15/16	3 11/64	2 5/16	63 - 400
10-62	24	10 1/8	5 7/8	3 35/64	61/64	3 3/16	2 5/16	63 - 400
10-63	24 1/2	10 1/2	5 61/64	3 9/16	31/32	3 7/32	2 5/16	63 - 400
10-67	27 1/2	11	6 1/4	3 43/64	1	3 25/64	2 5/16	63 - 400
10-71	30 1/4	11 1/2	6 9/16	3 47/64	1 1/32	3 39/64	2 5/16	63 - 400
10-72	31	11 1/2	6 9/16	3 25/32	1 1/32	3 39/64	2 5/16	63 - 400
10-75	32 5/8	11 1/2	6 3/4	3 53/64	1 1/16	3 45/64	2 5/16	63 - 400
10-77	34	12 3/4	6 13/16	3 59/64	1 3/32	3 45/64	2 5/16	63 - 400
10-81	48 3/4	18 1/2	7 11/16	4 13/32	1 1/4	4 17/64	2 5/8	70 - 400

NOTES:—

1. WHEN OTHER FINISHES ARE USED, CAPACITY, WEIGHT AND HEIGHT SPECIFICATIONS ARE ADJUSTABLE WITHIN THE REQUIREMENTS OF THE FINISH USED. SEE NOTE 2.
2. HEIGHT (DIMENSION 'A') IS BASED UPON USE OF SPECIMEN FINISH SHOWN.
3. THE SPECIFICATIONS SHOWN MAY VARY MODERATELY ACCORDING TO COMMERCIAL TOLERANCES AND INDIVIDUAL MANUFACTURER'S PRACTICE.
4. 'B' DIMENSION IS VARIED TO MAINTAIN CAPACITY.

STANDARD DIMENSIONS OF PLAIN ROUND JARS

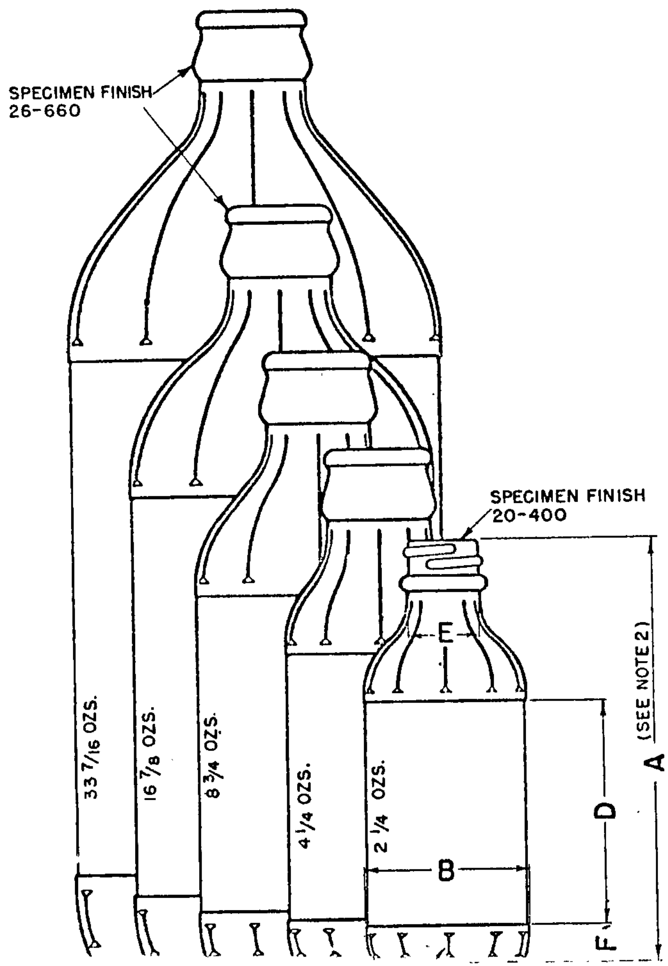


GCMI ITEM NO.	CAP. O'FLOW FL.OZS.	WT. MAX. OZS.	A	B MAX.	D	E	F	SPECIMEN FINISH
15-47	15	$6\frac{5}{8}$	$4\frac{1}{2}$	$3\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{15}{32}$	$\frac{3}{4}$	66-1710
15-53	17	$7\frac{1}{4}$	$4\frac{11}{16}$	$3\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{15}{32}$	$\frac{13}{16}$	66-1710
15-71	$28\frac{3}{8}$	$11\frac{1}{4}$	$4\frac{7}{8}$	$4\frac{3}{32}$	$2\frac{1}{4}$	$3\frac{9}{64}$	$1\frac{3}{64}$	83-1710

NOTES:—

1. WHEN OTHER FINISHES ARE USED, CAPACITY, WEIGHT AND HEIGHT SPECIFICATIONS ARE ADJUSTABLE WITHIN THE REQUIREMENTS OF THE FINISH USED. SEE NOTE 2.
2. HEIGHT (DIMENSION 'A') IS BASED UPON USE OF SPECIMEN FINISH SHOWN.
3. THE SPECIFICATIONS SHOWN MAY VARY MODERATELY ACCORDING TO COMMERCIAL TOLERANCES AND INDIVIDUAL MANUFACTURER'S PRACTICE.
4. 'B' DIMENSION IS VARIED TO MAINTAIN CAPACITY.

STANDARD DIMENSIONS OF SHOULDER-TYPE FRUIT AND VEGETABLE JARS

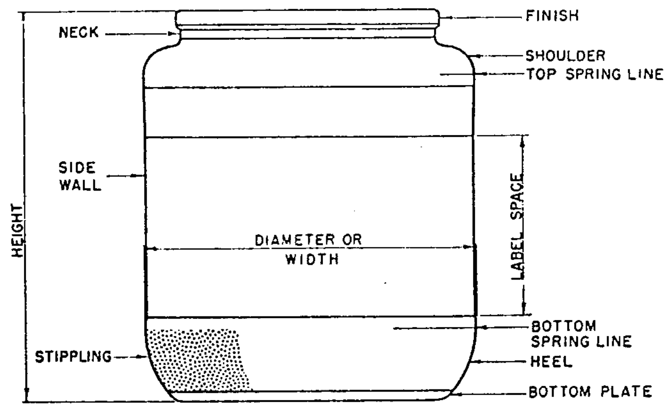


GCMI ITEM NO.	CAP. O'FLOW FL. OZS.	WT. MAX. OZS.	A	B MAX.	D	E	F	SPECIMEN FINISH
50-08	$2\frac{1}{4}$	3	$4\frac{3}{32}$	$1\frac{37}{64}$	$2\frac{5}{32}$	$\frac{11}{16}$	$\frac{3}{8}$	20-400
50-14	$4\frac{1}{4}$	$4\frac{1}{4}$	5	$1\frac{7}{8}$	$2\frac{9}{16}$	1	$\frac{7}{16}$	26-660
50-21	$6\frac{19}{32}$	$5\frac{1}{2}$	$5\frac{5}{8}$	$2\frac{5}{32}$	$2\frac{27}{32}$	1	$\frac{1}{2}$	26-660
50-28	$8\frac{3}{4}$	$6\frac{1}{2}$	$5\frac{31}{32}$	$2\frac{13}{32}$	$3\frac{1}{16}$	1	$\frac{17}{32}$	26-660
50-40	$12\frac{3}{4}$	$8\frac{1}{2}$	$6\frac{49}{64}$	$2\frac{11}{16}$	$3\frac{1}{2}$	1	$\frac{5}{8}$	26-660
50-5,	$16\frac{7}{8}$	$10\frac{1}{2}$	$7\frac{3}{8}$	$2\frac{61}{64}$	$3\frac{7}{8}$	1	$\frac{11}{16}$	26-660
50-52	$17\frac{3}{8}$	$10\frac{1}{2}$	$7\frac{3}{8}$	$2\frac{63}{64}$	$3\frac{7}{8}$	1	$\frac{11}{16}$	26-660
50-64	$25\frac{3}{8}$	14	$8\frac{3}{8}$	$3\frac{11}{32}$	$4\frac{7}{16}$	1	$\frac{25}{32}$	26-660
50-76	$33\frac{7}{16}$	17	$9\frac{5}{16}$	$3\frac{39}{64}$	5	1	$\frac{29}{32}$	26-660
50-91	$105\frac{5}{8}$	37	$10\frac{5}{32}$	$6\frac{5}{64}$	$4\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{7}{16}$	36-700

NOTES:—

1. WHEN OTHER FINISHES ARE USED, CAPACITY, WEIGHT AND HEIGHT SPECIFICATIONS ARE ADJUSTABLE WITHIN THE REQUIREMENTS OF THE FINISH USED. SEE NOTE 2.
2. HEIGHT (DIMENSION 'A') IS BASED UPON USE OF SPECIMEN FINISH SHOWN.
3. THE SPECIFICATIONS SHOWN MAY VARY MODERATELY ACCORDING TO COMMERCIAL TOLERANCES AND INDIVIDUAL MANUFACTURERS PRACTICE.
4. 'B' DIMENSION IS VARIED TO MAINTAIN CAPACITY.

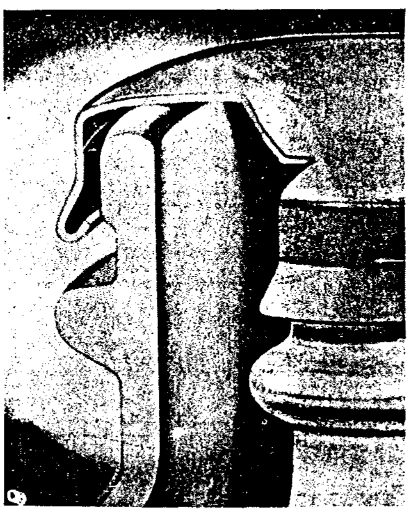
Standard Dimensions for Short Line, Round Food Line Glass Containers



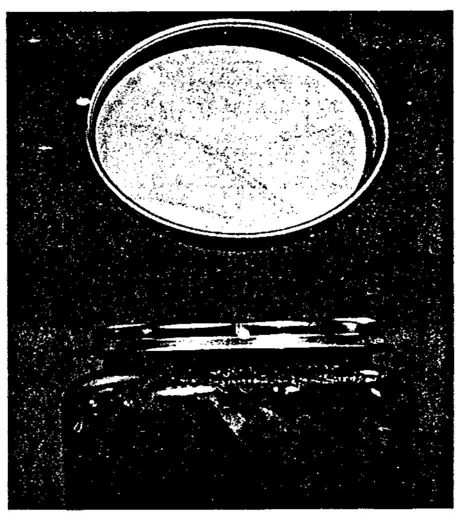
NOMENCLATURE FOR GLASS CONTAINERS FOR FOODS

Closures for Glass Containers

Hermetic closures are required for any food products which are subject to microbiological spoilage such as baby foods, prepared instant formulas, fruits, vegetables, meat products, juices, jams, jellies, preserves, tomato sauces, such as catsup and spaghetti sauce, chicken products, processed pet foods, pasteurized pickles, and many others where preservation by the use of heat is required. Functionally speaking, hermetic closures consist of a metal shell made of either tin plate or aluminum, an inside coating, and in impervious lining material. This material may be rubber, either natural or synthetic, a plastisol or sheet polyvinyl chloride material, or other suitable plastics.



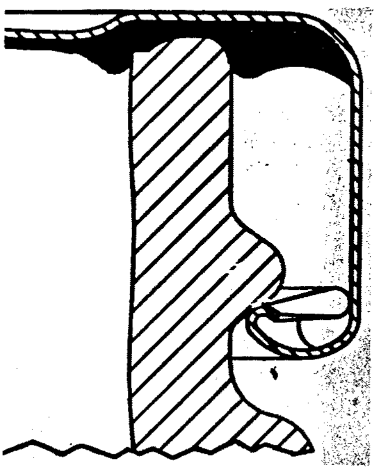
Pry-Off or Side Seal cap cross section on glass finish



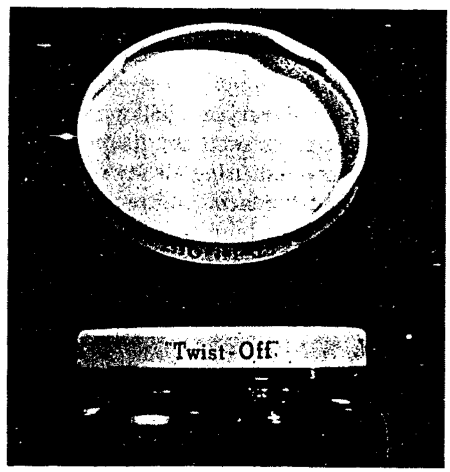
Side seal, pry-off cap and jar (Courtesy White Cap Div., Continental Can Co.)

Hermetic seals may be applied to packages in many different ways under many different conditions. They can be applied with a wide variety of capping equipment. Hermetic seals can be achieved by being pushed on, crimped on, rolled on, screwed on, or turned on as in the case of lug caps. They may be crowns, side seal closures, rolled on closures, screw caps or lug caps.

It should be noted that while all vacuum sealed packages must have hermetic seals not all packages with hermetic seals necessarily contain vacuum. For example, hermetic continuous thread (CT) closures are moving forward in areas where a vacuum seal is not required and the small amount of residual oxygen in the headspace is of little consequence. The liners here are mostly plastisol materials today, although there are still a few composition rubber lined closures on the market. These hermetic CT closures can be applied on regular CT capping equipment.



Schematic of
"Twist-Off" Cap on glass container finish



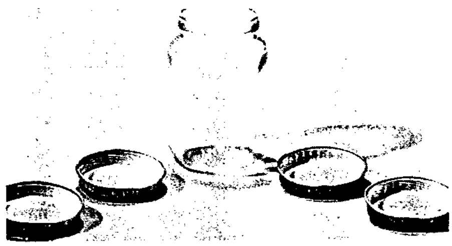
"Twist-Off" or Lug Cap
(Courtesy White Cap Div., Continental Can Co.)

The simplest procedure to produce vacuum in the finished package, using a hermetic seal, is simply to fill the product in at an elevated temperature. As the product cools and shrinks, a vacuum is produced in the container. Fruit juices and fruit drinks sealed with crown caps achieve a vacuum in this manner.

While the crown is not widely used on food products in the United States today, it is, along with similar types of crimped-on closures, widely used in other countries around the world.

Steam-vacuum applied closures are the most widely used vacuum seals in the U.S. food industry today. With steam-vacuum application the air in the headspace of the package is replaced with steam and the closure is applied. As the steam condenses, the vacuum is formed in the package. This is true whether the closure is roll-on, a side seal closure, a lug closure, or a push-on turn-off closure.

Press-Twist (PT) finish -- glass jar



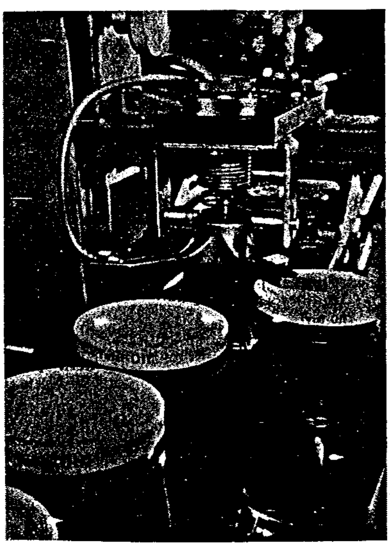
"PT (Press-Twist)" Cap
(Courtesy White Cap Div., Continental Can Co.)

The rubber lined side seal closure, applied with steam-vacuum, gives the greatest single impetus to packing processed foods in glass containers. A cut rubber gasket forms the seal against the glass finish in this closure.

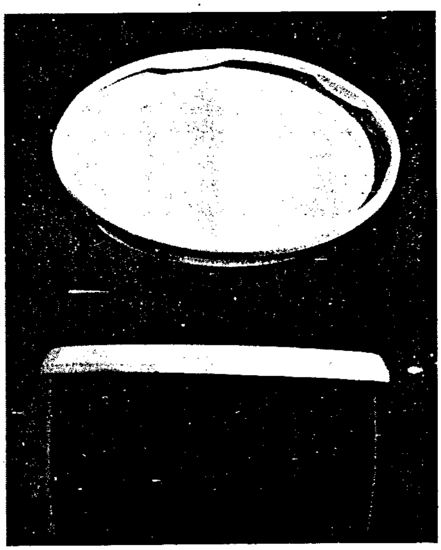
More recently plastisol lined closures for use on tumblers have been designed to provide a reseal factor which is not always present in the regular rubber lined closure.

Hermetic lug caps are used on a wide variety of products including fruits and vegetables, pickles, jams, jellies and preserves, fruit and vegetable juices, baby foods, tomato products such as catsup and spaghetti sauce and many, many others. It is normally applied using steam vacuum and because of extremely high production speeds and efficiencies, it is replacing many CT closures, even where the complete protection of the hermetic seal may not be required.

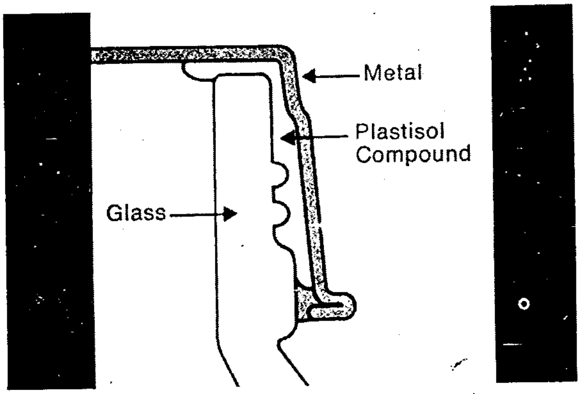
One of its major advantages is that it is easier to remove than the CT closure, especially under conditions of high vacuum. Also if there is a possibility of the food



Electronic dud detector
to automatically reject low-vacuum jars



Tumbler cap – DSR
(Courtesy White Cap Div., Continental Can Co.)



Schematic of "Press-Twist" cap on
glass finish
(Courtesy White Cap Div., Continental Can Co.)

product spilling over the finish of the container and on to the glass threads or lugs, it is easier to wash out the product from this area, a procedure which is virtually impossible with a CT cap, and again would make for easier cap removal.

The newest hermetic closure is a plastisol lined closure which is designed to be pressed onto the glass finish but which can be turned off and also resealed. Developed originally for baby food, its use is now spreading to a number of other heat processed products.

SHIPPING CASES

In past years much of our canned food was shipped in wooden boxes. Now, however, wooden boxes are used only for special export or other extraordinary shipments. Domestic shipments are in fiber boxes, either corrugated or solid fiberboard.

Cheap shipping containers are expensive at any price. There are standard specifications for both wooden and for fibre cases.

Cases for tin should fit fairly close; they should be the exact height of the can or tiers of cans, and only enough wider and longer to permit easy filling. An excess of an eighth of an inch in width and a quarter of an inch in length is ample, though when the casing is done directly from the labeling machine, the custom has been to allow more. The advantage of close packing, both in the lessening of damage to cases and contents, as well as in the conserving of shipping space has been conclusively demonstrated.

In the packing of glass the requirements for the outer container are the same as those for tin, but, glass being relatively fragile to impact from a non-resistant substance, requires that the container be provided with top and bottom pads, liners, and also interior partitions where the usual arrangements of bottles or jars are followed. The shipping specifications for products packed in glass provide for the minimum quality and thickness of material which may be used for these purposes.

Glass may be packed in jackets or individual wrappers and this is the more efficient method, but involves more labor. Corrugated fiber board has displaced almost all other kinds due to its economy, efficiency, and cleanliness.

Casing

Sometimes cans are still taken from the retort crates by hand and put into the cases direct. Other canners take the cans from the crate by hand but roll them to a boxing machine. Lately the entire crate is lifted and turned over by a special machine and the cans are straightened out by what is called an "unscrambler." They then roll to the labeling machine and the boxer.

The most common method today in use consists of casing the cans by means of boxing machines at the end of the canning line. Cans may be cased labeled or unlabeled and then taken to the warehouse. In some instances cans are warehoused uncased and unlabeled.

The new boxing machines are so constructed that the operator does not lift the filled case. It falls from the boxer on to a conveyor which takes the cases through the mechanical case sealing unit where both the top and the bottom flaps are sealed in place.

IN-PLANT QUALITY CONTROL

ORGANIZATION OF QUALITY CONTROL

Quality control in the food processing plant is generally assumed to have three basic aims:

1. To assure compliance with government regulations.
2. To maintain or improve the quality grade, thereby enhancing product value in the market place.
3. To reduce the probability of spoilage and resultant hazards to consumers and economic loss.

A wide range of attitudes toward the accomplishment of these aims exists in the industry. It is extremely difficult to estimate the value of a quality control department until an avoidable loss has been encountered due to a lack of such control. It is practically impossible to estimate the gains that might be realized by slight improvements in quality that would increase product value or saleability. Thus, there are plants in which little effort is expended on quality control measures and no definite program of any kind is followed.

Most certainly this condition exists, not because the processor would not like a quality control system, but rather that he does not realize how small the cost might be when compared to the risks involved. Too often, thoughts of quality control bring visions of spacious, gleaming laboratories full of complicated expensive equipment and even more expensive, apparently non productive, highly trained scientists. There is no denying that such laboratories do exist in the industry, but it is also true that they justify their existence and that they are no larger or more expensive than they need be.

The promulgation of the U.S. Food and Drug Administration Good Manufacturing Practices regulations for low-acid foods (Code of Federal Regulations, Title 21 Food and Drugs, Part 128b and Part 90, Sub-Parts A and B) makes it even more important to organize and maintain an efficient quality control program. Even though those regulations legally apply only to low-acid foods, canners of high-acid foods would be well advised to voluntarily apply pertinent portions of those regulations. That would contribute to improved finished product quality and to reducing incidence of canned food spoilage.

A quality control program can be started with a minimum of expenditure and expanded as the need arises. As a matter of hard fact, the laboratory is only one facet of quality control, being in essence a place where the results of quality control in the plant are checked. Much of the actual work should take place in the plant and should include an inspection of each phase of the operation to determine whether performance is satisfactory or where improvement can be made.

The first requirement for quality control is the designation of a quality control supervisor. If at all possible, this person should have no other duties, but if he must perform other functions, they should be subordinate to quality control. Also, while it is important that he cooperate in every way possible with the operating personnel, he should be directly responsible to top management.

The organization and operation of a quality control department may be discussed under three headings: first, qualifications required in the individual to be selected; second, laboratory requirements; and third, general operations.

Personnel Requirements

The degree of technical training required for quality control work is largely dependent on the size of the operation and the complexity of the foods being processed. The college-trained food technologist is, of course, ideally suited for this type of work providing the plant production justifies employing such an individual. For smaller plants, or those operating only on seasonal products, it has been found that the work can be carried on without formally trained personnel, by selecting an individual who is experienced in the details of the plant operation and training him specifically for the work required. A person with real interest in the type of work is essential and, or course, some technical background is highly desirable.

If the plant operations justify only a part-time employee, a college student or high school or college science teacher may be the most practical type of person for quality control work. If at all possible, however, the quality control work should be assigned to a year-round employee as the full benefit of such a program can only be obtained when continued on a year to year basis.

Aside from the quality control aspects, a more highly trained individual might be able to use some of his off-season time in developing new products that fit in with present operations or assist in devising new methods of preparing old products.

Additional personnel should be employed where the nature of the product requires constant routine laboratory work—for example mold and insect fragment counts for tomato products or moisture tests for corn. Summer help is entirely satisfactory for such duties.

Laboratory Facilities

The laboratory need not be elaborate nor large. A square room, approximately 18 ft. x 18 ft. will provide ample working space as well as storage areas for retaining samples and an incubator which may be added later. The room should be well lighted and apart from but with easy access to the processing floor. A minimum of 20 linear feet of bench space is highly desirable. The room should be supplied with electric power and running water at a sink. Provision should be made for the collection and disposal of refuse.

A desk for the preparation of records and reports as well as a file cabinet to store them are necessary. The value of the control program increases with the years and is dependent on the availability of data.

Equipment requirements will vary considerably with the products packed, but basic items include a hot plate, a heavy duty can opener, vacuum gauges, headspace gauges, a scale, a set of drained weight screens, size grading screens, grading trays, and a can center temperature device if fruits or acidified products are packed. A hydrometer calibrated in percent salt will be found useful and where syrup packs are made, a set of syrup hydrometers or a refractometer are necessary. Tomato products make a microscope a must. A simple chlorine test kit is a worthy addition.

General Operations

In general, the operations of the quality control department may be divided into three areas: inspection and grading of raw product, control of processing operations, and examination of finished packages. Before any of these functions can be carried out, it should be clearly understood in detail, what is wanted at each step of the manufacturing procedure, and what specifications or standards are expected in the finished product.

Towards this end it is suggested that the first function of quality control be the preparation of a *plant operating manual.* This manual should be prepared in cooperation with management and the key production personnel and should represent the combined company know-how for each canning operation, such as segregation of raw product for the various quality grades (for example, Tenderometer grades for peas or moisture content for corn), blanching schedules for various products or grades, fill-in weights, syrup or brine concentrations, closing temperatures and sterilizing processes. Production capacities should be set up so that proper supplies of raw materials will be available to prevent starving operations with resultant costly production interruptions or causing an over supply of perishable produce that spoils or is downgraded on the plant dock.

Product specifications should also be set up in written form to include net or drained weights, headspace and where applicable such data as unit count, consistency, syrup cut-out concentration and other pertinent information. This manual should be reviewed annually and brought up to date as additional experience is acquired. By the use of the manual as a guide, the operation of quality control resolves itself into the periodic inspection of the raw product and each step of the processing procedure to determine whether the prescribed methods are being followed, and daily examination of packaged samples to determine whether the finished product conforms to the standard desired.

Cooperation with the *field department* is an important feature of the quality control program. It is necessary that each group understands the problems and goals of the other. No finished product can be any better than the raw material supplied it nor should impractical quality levels be set that would reduce yields to an uneconomic level. Wherever possible, objective test methods should be used or sought to minimize misunderstandings, and such tests, when used on individual lots or loads, may speed handling in the cannery.

An overall visual appraisal of *raw material* when it arrives and a periodic check as it awaits processing should not be forgotten. It is important to foresee deterioration due to delay in transportation, handling, weather conditions or maturity and to recommend steps to forestall the effects of such deterioration. For example, rapid handling of a particular lot may prevent the need for extra inspection, additional trimming or production loss.

CONTROL OF FACTORY OPERATIONS

At the time of instituting the quality control program, an initial inspection should be made of the plant equipment for conditions which are not compatible with good canning practices. If possible, this should be done before the start of the canning season. One purpose of such inspection should be to check the equipment for possible sources of metallic contamination. Copper is a particular offender in this regard; it causes discoloration in products such as peas and corn, and may act as a corrosion accelerator when present in apple juice and other fruit products.

This metal may be contributed by equipment made from copper or copper-bearing alloys such as brass, bronze, or Monel metal. Such metals should not be used for kettles, brine tanks, brine lines, valves, fillers or other equipment contacting the product during preparation.

Filler parts of certain other equipment made from these metals may be plated with a non-corrosible metal if replacement is not economically feasible. Iron may also cause discoloration in some products, although no problems are ordinarily encountered if the equipment is kept free of loose rust. Product contact parts should be made of # 304 or #316 stainless steel, glass, or approved plastics. #316 stainless steel is more corrosion resistant to food acids than #304.

Another objective of the initial plant inspection should be to check for obvious spoilage hazards such as wooden equipment and worn or porous conveyor belts. Such porous materials in contact with the product during preparation become seeded with spoilage organisms and, being practically impossible to clean, act as a source of infection to contaminate the product subsequently run through the line. Contact of product with wood should be avoided.

Wooden equipment should be replaced with metal, and worn belting should be replaced. Other spoilage hazards such as "dead ends" in brine or product lines may also be noted during such an inspection. As previously mentioned, this equipment inspection should be made well in advance of the actual canning season in order that the necessary changes or replacements may be carried out.

Attention may also be given to the condition of the retort and other sterilization equipment during this pre-season inspection. Steps should be taken to see that automatic pressure controls and recorders are in proper working order, and thermometers and pressure gauges should also be checked for accuracy. Sterilization equipment piping in general should also be examined to make certain that the hook-up, pipe sizes, safety valves, and venting provisions are in accordance with latest recommendations. For low-acid foods, pay special attention to the FDA Good Manufacturing Practices regulations.

Daily Sanitation Survey

Before the start of each day's operations, an inspection should be made to check the sanitary condition of the equipment in the canning line.

This should be in addition to any inspection made by the foreman in each department, and any evidence of poor clean-up of the equipment should be reported so that the condition may be corrected before canning operations are begun. Particular attention should be given to cream style corn fillers, where the parts may appear clean on superficial examination but a film of starch material may harbor spoilage organisms.

Observation should also be made for other potential spoilage hazards such as leaky steam valves permitting blanchers, blending tanks, or similar equipment to be heated within the thermophilic growth range during non-operating periods, hold-over of syrup at temperatures favorable to bacterial growth, or inadequately drained syrup or brine lines.

The quality control technologist should at all times be on the alert for operating practices which may represent possible spoilage hazards since such conditions may frequently be overlooked by the production personnel, particularly during periods of heavy production.

Daily Plant Inspections

At the beginning of each day's pack and, if possible, at two hour intervals during the day, the various steps in the *canning procedure* should be checked by the quality control man. These inspections should be made according to a definite plan, and the points checked should be recorded on a form appropriate to the particular product. The forms should be prepared in duplicate; one copy for the plant manager, and the other to be kept on file in the laboratory.

In addition to the written report, any deviations in operating procedure should be reported immediately to the department involved.

As mentioned earlier, the periodic inspections of the plant operations should begin with the *raw product;* noting the quality, condition, and if applicable, the quality grade or product on hand. Proceeding along the canning line, the efficiency of washing, sorting, and trimming operations should be noted. In washing operations making use of recirculated water, the condition of the wash water, and quantity of fresh make-up water should be observed.

In such preliminary cleaning operations the rate at which the product is being fed into the equipment is also closely related to cleaning efficiency.

Sorting and trimming efficiency likewise may be hampered if the line is being overloaded. The latter operations should also be observed for evidence of excessive waste from overtrimming, particularly at the beginning of the season or where inexperienced help is involved.

At the *blanchers*, observations should include time and temperature of the blanch, amount of make-up water being added, and concentration of salt or other blanching supplements, if used. If tubular blanchers are employed, the water recovery tanks should be observed for excessive foam accumulation as such conditions have been found conductive to a build-up of thermophilic spoilage organisms. The temperature of the recirculated water should also be checked to insure that the entire system is maintained at a temperature above the thermophilic growth range.

Details of the daily inspections of the intermediate operations in the canning line will, of course, depend upon the type of product being packed. Tomato juice and related products require particular emphasis at the sorting and trimming belts to reduce mold content, and microscopic examination of each batch of product is essential in this regard.

Operations on fruits or vegetables, such as lye peeling, coring, slicing, dicing, or comminuting should also be observed at each plant inspection and the appropriate notes made a part of the daily record.

The filling operation should receive special attention. The filler operator should make frequent weight checks to make certain that the fills are within the desired limits for the product, size, and grade being run. The quality control man, in turn, should check this running record at each inspection interval as well as actually observing the appearance of the cans leaving the filler.

When weight checks are made, consecutive cans should be sampled from each filler pocket to insure that all pockets are operating properly. Statistical methods have been developed to evaluate the operation of fillers and to determine whether the desired fill-in weights are being obtained.

However, where the quality control technologist is not trained in statistics frequent weight checks kept in writing will furnish the desired information. If the range between minimum and maximum fills cannot be held within reasonable limits, the filler should be checked for mechanical defects or improper adjustment. Brine or syrup temperature and fill should also be noted at the filler, and concentration of these media should be checked in the syrup or brine preparation room.

Terminal exhausts, if used, should also be checked for exhaust box temperature and average product temperature after exhausting.

Operation of the *closing machine* should also be given careful attention. Actual adjustment of the machine and maintenance of good seams are the responsibility of the closing machine operator, and this individual should examine and measure seams at the start of each run and at intervals of one to two hours during the pack.

The operator should also make a note of any machine changes or adjustments and this information together with the closing machine count at the time such change is made, should be part of the permanent record. The quality control man should be responsible for checking the record of hourly seam measurements and should collect the operator's report for filing at the end of each day.

Visual observation of the cans at the discharge of the closing machine may also prove helpful in detecting certain types of machine failure, such as a broken chuck or seaming roll, which might occur between periodic seam inspections by the closing machine operator. The quality control man should also note the vacuum (if vacuum closure is used) or, if steam flow closure is employed, the efficiency of this operation should be checked periodically. Average product temperature at the time of closure should also be recorded.

Proper retort operation, as well as that of other sterilization equipment, is one of the most critical steps in the entire canning procedure and should receive careful attention in the periodic quality control checks. Any abnormal delay between closure and processing of the cans should be noted, as well as the actual operation of the sterilization equipment. Venting during the come-up period in retorts is particularly important, as entrapped air in the retort may cause "cold spots" and result in under-processing portions of the retort load.

Recommended venting schedules are available for various sizes and types of sterilization equipment and the proper venting procedure, once determined for the particular plant conditions, should be checked both as to time and indicated temperature before the vents are closed.

The time and temperature of processing for each can size should be checked, and where temperature recorders are used, the charts should be collected each day. Before filing, the charts should be checked carefully and any irregularity in come-up or processing time should be reported immediately.

Where pressure cooling is employed this procedure should be checked periodically, and the cans as removed from the retort should also be observed for evidence of buckling or paneling. The temperature of the containers at the completion of the cooling cycle should also be determined and recorded.

If chlorination of the cooling water is employed, the residual chlorine content should be checked at each inspection.

If whole tomatoes or fruit products are packed, *can-center temperatures* should be determined at the end of the process in addition to recording the time and temperature of processing. Adjustment of the processing time may be necessary as the maturity or condition of the fruit changes during the season.

The plant inspection should also include periodic examination of the *warehouse*. Evidence of spoilage should be looked for and the incidence of any rusted containers noted. The technologist should also be on the alert for indications of can damage due to rough handling, maladjusted runways, or damage in unscramblers, labelers, or casing machines. A record of warehouse temperatures may also prove useful for future reference.

Examination of Line Samples

In addition to observations of the canning procedure to determine compliance with operating instructions and federal and state regulations, the quality control laboratory should conduct a daily examination and grading of line samples to check the finished product against the desired specifications set up by the management. Samples for laboratory examination may conveniently be obtained during the plant inspection. It is suggested that a minimum of two cans from each line be collected every two hours, or from each lot change if this occurs more frequently. One can, properly identified, should be retained for possible future reference and the other can from each sampling should be examined immediately.

The examination to be made will vary somewhat with the product. In general, the data should include net weight, vacuum, headspace, drained weight (if applicable), and general observations for unit size, color, flavor, texture, defects, extraneous material, and compliance with any other specification under which the canner is operating. Syrup packed fruits should also be checked for cut-out syrup concentration. Where needed, special instruments may be utilized to assist in grading the product for additional factors such as color, maturity, viscosity, specific gravity, pH, or total acidity.

Control of the pH is very important where acidification of the product is employed to permit the use of a boiling water process.

Data obtained in the examination of canned samples should, of course, be recorded on a form prepared for the particular product. Identifying information such as can size, embossed code, date and time of packing should also be a part of the record.

The quality control man, through his daily plant inspections, may be of invaluable assistance in pin-pointing the responsibility for the deviations noted.

Control should also be exercised over certain critical ingredients such as sugar, starch, salt, and spices. Laboratory examination of these materials at the canning plant may not be feasible, particularly where bacteriological tests are involved, but the quality control technologist should set up purchasing specifications and, if necessary, samples may be submitted to outside laboratories for examination.

Examination of Water

Water may also be considered an important ingredient in canned food products. The texture of certain vegetables, such as peas and dried beans, may be adversely affected by excessive water hardness, particularly calcium and magnesium salts, and if this problem exists, softening of the water may be necessary. Checking the operation of the water softener would then become a function of quality control.

The bacteriological condition of water in the plant is also important from the standpoint of spoilage prevention, and where in-plant chlorination of the water supply or treatment of the cooling water is employed, the effectiveness of the chlorination should be checked periodically by quality control to make certain that the desired results are obtained.

Some form of boiler water treatment is also necessary in many plants, and quality control may serve as a check on certain abnormal boiler practices. Inadequate treatment of the boiler water, or improper boiler operation, may adversely affect the processed cans by causing external detinning, removal of outside enamel or lithography, or by the formation of an unsightly white deposit on the cans.

In examining cans after processing and cooling, the quality control technologist should be on the alert for conditions of this type in order that an immediate check of the boiler operation may be made to determine the source of the difficulty.

TESTING CANNED FOODS

Following are descriptions of some of the laboratory procedures used more generally to ascertain quality of canned foods for determination of compliance with grade and standards. For a more comprehensive explanation of these tests the National Canners Association publication "Laboratory Manual for Food Canners and Processors" may be consulted. That publication also includes other laboratory procedures used by the canning industry.

Vacuum

For taking the vacuum the can or jar lid is punctured with a vacuum gauge. The lid should be punctured near the edge to minimize deformation of the lid by the pressure required to penetrate it. Cans should be read at room temperature because a warm can will have a lower vacuum and a cold can a higher vacuum than they would have at room temperature. Readings on severely dented cans are lower than readings on normal cans. A reading on a can that is completely full or which contains too small a headspace is not always accurate, because the gauge tip may penetrate the product and fail to register, or the air in the gauge itself may produce a large error causing the reading to be much too low.

Also available (American Can Company) is a portable electronic device for checking the condition of cans and glass containers inside sealed cases. The instrument taps on cans electronically. Frequency of tone heard indicates degree of vacuum or pressure in container.

Headspace

The gross headspace is the vertical distance from the top of the double seam of a can or the top edge of a glass jar to the level of the product in the container. In determining this distance the headspace gauge is placed in such a position that the measuring rod can descend in a vertical position to the approximate center of the can. The rod is slowly pushed down until the end just penetrates the surface of the liquid. The point of intersection of the rule with the horizontal bar is then read. Headspace is customarily read in 1/32 inches.

In some instances the solid portion of the product may extend above the liquid, and must be pushed below the liquid level before the headspace is measured. In case the product will not remain below the liquid while the headspace measurement is being taken, it must be held down with a depressor. If a depressor is used, a correction equivalent to its liquid displacement should be added to the measured headspace.

The net headspace of a container having a double seam, such as a can, is the distance from the liquid level to the inside surface of the lid. This may be estimated by subtracting from the gross headspace 6/32 of an inch, which is the average height of the double seam.

Fill of Container—Cans

It is generally assumed in the canning industry that a container must be filled to not less than 90% of its total capacity. This is the standard of fill of container promulgated under the U. S. Food and Drug Law for canned tomatoes, cream style corn, and pineapple juice. It is also included as a general requirement by the Agricultural Consumer and Marketing Service of the USDA for establishing product grades for which no standard of fill of container has been promulgated. This requirement can be taken to mean that the net headspace of the container should not be greater than 10% of its internal height. It is possible, therefore, to compute the maximum gross headspace which is permissible in each size container.

The following formula may be used to calculate percent fill:

$$\text{Percent Fill} = 100 - (\text{Net Headspace}) \times C$$

$$\text{where } C = \text{Percent Can Capacity per 1/32nd inch Headspace}$$

If a table of capacity of can per 1/32nd inch headspace is not available, calculate the inside height of the can by subtracting 12/32-inch from the total height of the can measured to the nearest 32nd inch and determine the net headspace of the contents by subtracting 6/32-inch from the gross headspace. The percent fill is obtained by subtracting the net headspace from the calculated inside height of the can, dividing this difference by the inside height of the can, and multiplying by 100.

$$\text{Percent Fill} = \frac{\text{inside height of can} - \text{net headspace}}{\text{Inside height of can}} \times 100$$

The validity of the measurement for fill of container described above assumes that the can is of uniform cross section area throughout its height. Dents, panels and end distortion render the measurements inaccurate. Fill of container should not be determined on this type of container unless a sizeable correction can be made for the abnormality of shape.

Fill of Container-Glass Jars

In determining the fill of container of products packed in glass jars the weight of water required to fill the jar level with the top (overflow capacity) is used in place of the "water capacity" as determined for cans. Because the diameters of glass jars usually are not exactly the same from top to bottom, the simplified method of obtaining percent fill cannot be used, but measurements of the weight of water required to fill the container to the actual headspace must be made.

The percent fill can be calculated as follows:

$$\text{Percent Fill (jars)} = \frac{\text{weight of water to actual headspace}}{\text{overflow capacity}} \times 100$$

Fill of Container-Juice Products

In addition to determining if the product meets the general requirement of 90% fill described in the previous section, it is frequently necessary to know the volume fill in fluid ounces or cubic centimeters. This may be calculated from the weight of water at 68°F required to fill the container to the actual headspace of the product. The following factors may be helpful in converting from avoirdupois ounces of water at 68°F to fluid ounces and cubic centimeters.

Capacity in fluid ounces = Avoirdupois ounces of water at 20°C × 0.9603

Capacity in cubic centimeters = Avoirdupois ounces of water at 20°C × 28.40

Fluid ounces = Cubic Centimeters / 0.03382

Drained Weight

Some of the USDA Standards for Grades of Canned Foods specify minimum drained weights for the product covered by the Standards.

Drained weight is determined by emptying the contents of a container upon the meshes of a circular screen. For all products except tomatoes an 8-mesh screen (0.097 in. sq. openings) and for tomatoes a 2-mesh screen (0.446 in. openings with the wire 0.054 in. in diam.) is used. For cans containing less than 48 oz. an 8 in. screen is required, while for cans containing more than 48 oz. the screen should be 12 in. in diameter. All products except spinach are distributed evenly over the meshes of the sieve. Cut fruit is turned by hand to the cup down position so that the liquid can drain out of the cups. Except in the case of spinach, the screen is tilted so that one side is approximately two inches higher than the other. This may be accomplished by placing the sieve in a pan with one edge resting on the raised edge of the pan. Spinach is drained by removing the lid and inverting the can on the draining screen, after which the can is gently raised leaving the spinach in a mound. The spinach is not disturbed during the draining period and the screen is not tilted, but the meshes of the screen should be raised above the bottom of the pan sufficiently to permit free drainage of liquid.

Exactly two minutes after the product is placed on the screen the drained solids are weighed by one of the following procedures:

A) The screen containing the drained solids is placed directly on the balance and weighed; the weight of the draining screen is then subtracted. When several drained weights are to be determined, the additional weight of liquid which has seeped into cracks in the screen and cannot be wiped out during cleaning should be included in the tare (this is usually 0.05-0.10 oz.). The liquid which continues to drain from the screen is held by the balance pan, or a separate pan must be tared with the screen to catch the drainings. For the most accurate work, the screen should be clean and dried between each sample. Sample should be weighed to 0.1 oz.

B) The solids are transferred from the draining screen to a tared pan or dish and weighed to 0.1 oz. In this method the liquid which clings to the meshes of the draining screen is not weighed and the resulting drained weights are slightly lower than those obtained in method A. The difference is less in samples containing non-viscous syrup or brine than in samples with viscous syrup.

Method A is specified in U. S. Food and Drug standards for fruit cocktail, tomatoes, corn and green beans for separating solid and liquid portions. It is also specified by the Agricultural Consumer and Marketing Service for U. S. grades.

Method B is used for determining the drained weights of peas and pineapple, and in California for determining the drained weight of spinach.

CUT-OUT BRIX

This shows the amount of soluble solids in the liquid portion of canned fruits in terms of percent by weight of sugar. (Almost all of these solids are sugar and for practical purposes may be regarded as sugar.) The sugar in the liquid is a mixture of the sugar added to the can in the syrup used as a packing medium and the sugar dissolved out of the fruit in the can. The final concentration or Cut out Brix therefore depends on four factors:

1. The weight of fruit in the can
2. The per cent of sugar in the fruit
3. The weight of syrup added to the can
4. The per cent of sugar in the syrup (Brix)

With small units, such as cherries, the weight of fruit and of added syrup in each can is quite uniform and the Cut-Out Brix of successive cans will be similarly close to each other. But with large units, such as large half-pears, the weight of fruit that can be put in each can varies greatly. The amount of syrup that can be added varies similarly and the Cut-Out Brix of successive cans will show large variations.

The Cut-Out Brix may be determined with a Brix hydrometer (or Saccharometer). Two hydrometers should be provided, one reading from 10 to 20 and the other from 20 to 30 percent. Also a glass or metal cylinder of about 200 milliliters capacity. The hydrometers should be graduated at 68 degrees F rather than any lower temperature. When the hydrometer has come to rest in the syrup in the cylinder the reading should be taken at the level of the liquid rather than where the liquid rises around the stem of the hydrometer.

The Cut-Out Brix may also be determined with a refractometer. Only one drop of the liquid is needed. Some refractometers have a sugar scale also which will show the Brix direct. When only the refractive index is given it is necessary to use a conversion table to show the Cut-Out Brix. The table above shows the relation between the refractive index at 68 degrees F and the percent by weight of sugar (Brix).

For strict accuracy, it is necessary to take the temperature of the syrup at the time the brix is determine–by either the spindle or the refractometer, and make a correction. If the determination is made at ordinary room temperature the correction is small. Prior to making Brix readings, the refractometer should be adjusted to read a refractive index of 1.3330 for distilled water at 68° F.

Per Cent Sugar (Brix)	Refractive Index 68 Degrees F.	Per Cent Sugar (Brix)	Refractive Index 68 Degrees F.
10	1.3478	41	1.4016
11	1.3494	42	1.4036
12	1.3505	43	1.4056
13	1.3525	44	1.4076
14	1.3541	45	1.4096
15	1.3557	46	1.4117
16	1.3573	47	1.4137
17	1.3589	48	1.4158
18	1.3605	49	1.4179
19	1.3622	50	1.4200
20	1.3638	51	1.4221
21	1.3655	52	1.4242
22	1.3672	53	1.4264
23	1.3689	54	1.4285
24	1.3708	55	1.4307
25	1.3723	56	1.4329
26	1.3740	57	1.4351
27	1.3758	58	1.4373
28	1.3775	59	1.4396
29	1.3793	60	1.4418
30	1.3811	61	1.4441
31	1.3829	62	1.4464
32	1.3847	63	1.4486
33	1.3865	64	1.4509
34	1.3883	65	1.4532
35	1.3902	66	1.4555
36	1.3920	67	1.4579
37	1.3939	68	1.4603
38	1.3958	69	1.4627
39	1.3978	70	1.4651
40	1.3997		

Flavor

It is advisable to include flavor evaluation as a responsibility of the quality control department. The quality control supervisor should select the flavor evaluation test that he deems adequate for the product under consideration.

Net Weight

This is determined by subtracting the weight of the dried empty container from the weight of the full container. It is usually reported to the nearest 0.1 oz.

pH Measurement

pH measurements are now made almost exclusively with glass electrode pH meters. The determination is usually made on a small amount of syrup or brine poured from the can into a beaker, but in some instances the electrodes may be inserted directly into the can. In the latter case the can should be placed on some non-conducting surface to avoid currect fluctuations.

Total Acidity

For routine work, acidity usually is determined on a 10 ml sample of syrup or brine, but for greater accuracy a 10 gram sample of the entire can contents, after blending, should be used. Electrode pH meters or electrometric titrimeters are being used more and more in place of visual indicators to detect titration end points. Samples should be titrated to an end point of 8.1, which corresponds approximately to the phenolphthalein end point. Results are expressed as percent of anhydrous citric acid with the following exceptions: grapes and grape juice as tartaric acid; apples and apple juice as malic acid; catsup and various hot sauces as acetic acid; and sauerkraut and other fermented products as lactic acid.

PURCHASING RAW PRODUCTS FOR CANNING

Most products are bought on the basis of some specifications. Much progress has been made in developing more precise descriptions of the kinds of materials the canner must have in order to produce the types of canned product he wants. Instruments, such as the Tenderometer for testing raw peas, the shear-press for determining food texture and firmness, and color and color difference instruments have been devised to assist in the accurate appraisal of many products.

Certain of the specifications are in the form of Official Government Grades. Some State Marketing Bureaus have their special standards. Canners groups such as the Canners League of California have assisted their members in purchasing fruits. Each canner can avail himself of any or all of this information in formulating a buying policy to fit his particular circumstances.

Each lot of produce should be examined at the factory and paid for on the basis of its quality for canning and yield of canned product. Usually the canner enters into a contract with each grower for the purchase of all of the produce from a stated number of acres on the basis of the suitability for canning of each load as it is delivered to the factory. The canner pays more for carefully selected produce than for the field-run delivery.

It is possible for the canner to employ official graders to test each load. This is usually done through an agreement with the State Department of Agriculture or other appropriate agency. Many canners do their own testing. Carefully worded specifications that are thoroughly understood by both the grower and the canner help to preserve the friendly relations that are so essential to a continuing and expanding industry.

Many canners employ one or more "Field men" to keep track of the produce that is to be canned. These men are in frequent touch with each grower all through the season. Usually the canner furnishes the seed so that he will get a particular variety that is wanted. The more desirable varieties of fruits and vegetables usually bring higher prices to the growers. The time of planting is regulated to try to spread the canning season over as long a period as possible. The field man says when each plot is to be harvested. Only by such far-sighted planning can an operator be sure of enough tonnage of the right produce to keep his factory running efficiently.

CANNING OPERATIONS

PRE-PROCESSING

Bulk Storage Processing of Tomato Products

The tomato industry has made termendous advances in the past 50 years. New cultivars and cultural practices, improved and enlarged processing equipment and facilities, and streamlined warehousing and marketing practices have kept the industry constantly growing. However, the industry is still faced with a number of serious problems even with the past innovations. Some of the more serious problems include short labor supply, processing bottlenecks, over-production of certain products, large equipment investment, large warehousing costs, and raw product scheduling. Until the problem of seasonality is diminished, the tomato industry can not be freed to become more efficient and orderly in their processing and marketing functions. One solution would be to enhance the holdability of partially processed fruit at some step of processing. By extending the storage life of partially processed fruit to allow year-around plant operations, the problems of seasonality could be sharply reduced. The development of bulk storage processing can assist in this problem.

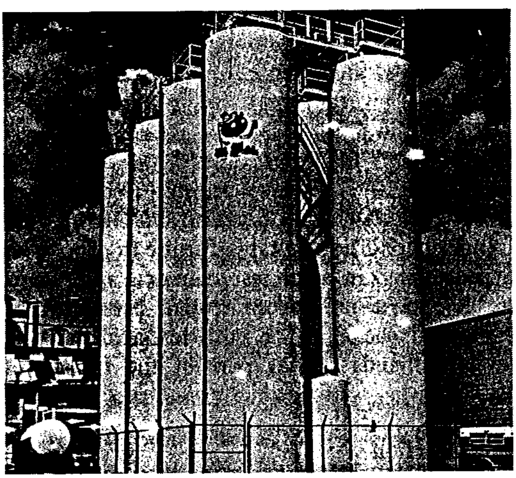
Very little literature concerning the processing of tomato products for bulk storage is available. However, data obtained with conventionally processed products point to factors that are important to consider in bulk storage processing. These include 1) rapid pectic enzyme inactivation to maintain high viscosity, 2) high temperature treatment to destroy spore forming bacteria, and 3) protection of the sterile product to prevent microbial recontamination and exposure to oxygen.

The Process. Bulk storage as the name implies is holding a large unit of food under storage conditions that prevent spoilage. The stored product is held for later remanufacture. The concept is simple but the technology required to assure product protection under bulk storage conditions is considerably more demanding. An industry-university (Purdue University – The Bishopric Products Co.) research project resulted in a process designed to store products from single strength juices to highly concentrated material.

The Purdue-Bishopric process can be broken down into two areas: (1) Tank sterilization and (2) product sterilization.

Tank construction and sterilization. The large, nonrefrigerated tanks are composed of carbon steel, lined with Bishopric "Lastiglas" lining. The tanks are either shop or field constructed depending upon size. There are two openings in the tank. A top manway permits the introduction of a sprayball for CIP washing, a N_2 gas inlet equipped with a microbial filter and two sight glasses. A 4-inch opening placed in the conical bottom of the tank allows for filling and emptying.

Valves that come in contact with the sterile product must be aseptic. In the system designed by The Bishopric Products Co. special patented valves are used to prevent microbial contamination from the atmosphere. Special chambers that encompass the valve stems allow the circulation of a chemical sterilant, such as a halogen. By using this technique, the problem of requiring culinary steam and localized overheating of the product is overcome. When closed, the valve seats are also protected by the chamical solution. Once throughly cleaned, the tanks are sterilized by contact with a halogen solution at a concentration of approximately 20 ppm. The tanks are then purged with sterile N_2 gas, sealed, and are ready to accept sterile product. This cleaning and sterilizing procedure may be accomplished well ahead of the processing season.



TOMATO STORAGE – Research at Purdue University to develop a better method of storing semi-processed tomatoes led to the construction of 40,000-gallon aseptic food storage tanks by The Bishopric Products Co., of Cincinnati, Ohio. During harvest season the tanks are filled with tomatoes to await further processing or transporting.

(Courtesty Agricultural Information Department, Purdue University, W. Lafayette, Indiana)

Product sterilization and transfer. Conventional sterilization practices can be used to sterilize tomato products. With product below 16% solids a process equivalent of 250° F for 0.7 min. is required. At 18% solids or higher heating to 190° F should be adequate. In all instances the sterile product is cooled to below 90° F before introduction into the tanks. All transfer lines are presterilized with hot water prior to operations with positive pressure maintained on the sterile product at all times. It is important that the system be so designed that only properly sterilized product be allowed to enter the tanks. This requires a control system and recycle or bypass lines.

The system should be so designed to permit partial filling of the tanks during one operation with complete filling at a later date. Likewise, partial emptying of the tanks can be accomplished by replacing the removed product volume with sterile N_2 gas. Periodic microbial and quality monitoring should be carried out.

Other products such as applesauce, cranberry sauce, grape juice, and orange concentrate have also been successfully bulk-stored. While each product has its own specific processing requirement, the basic bulk storage technology can be adapted for each product.

Bulk storage breakthroughs have also allowed the shipment of preprocessed product in bulk. These sterile products are shipped in nonrefrigerated tanks by truck and rail for final processing at distant processing facilities. This makes it possible to produce the raw solids in optimum growing areas and final-process them in distant consumption areas. Avoiding the shipment of ingredients, bottles, cans and cartons greatly reduces transportation costs.

Bulk storage technology is expected to have a significant impact on the fruit and vegetable processing industries.

Receiving Raw Products and Packaging Materials

Incoming raw materials, ingredients, and packaging components should be inspected upon receipt to ensure that they are suitable for processing. Raw materials should be received in an area separate from the processing areas. Prior to being placed in inventory, ingredients susceptible to microbiological contamination which would render them unsuitable for processing either should be examined for microbiological condition or should be received under a supplier's guarantee that they are of microbiological condition suitable for use in processing. Products should be held prior to processing in such a manner as to minimize growth of microorganisms. All the above are recommended procedures to be followed in receiving raw materials and packages for both low-acid and high-acid foods. For low-acid foods they are mandatory as part of the FDA Good Manufacturing Practices regulations.

Separation of the Edible Portion

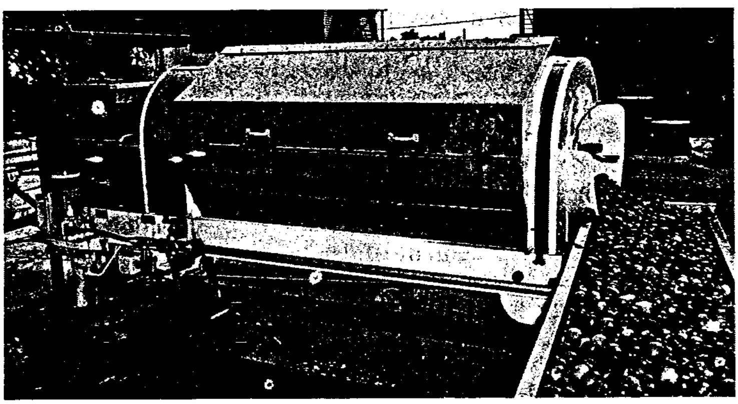
Many products as received at the factory require some special treatment to separate the edible portion. Peas must be removed from the shells (vined); fruit must be peeled and cored; corn must be husked; fish must be cleaned; etc. For each such operation special machinery has been developed so that a large amount can be handled quickly. The canning season for each product is usually short and the canner must install sufficient machinery to care for his requirements.

Washing

Immediately upon receipt at the cannery, raw food materials are thoroughly washed. Washing has obviously the objectives of separating soil and foreign materials, but it also considerably reduces the load of spoilage bacteria naturally present in foods. Reduction of numbers of bacteria present increases the effectiveness of the sterilization process. Washing also improves the quality and appearance of the foods.

Washing is done by equipment in which the products are subject to high pressure water sprays or strong flowing streams of water while passing along a moving belt or while being tumbled on agitating or revolving screens. Sometimes a flotation type of washer is also used to remove chaff or other extraneous material. Washing is sometimes preceded by mechanical removal of soil and other fine materials that adhere to the food. Stones and other heavy objects are also separated.

In some canning procedures, operations whose functions are not primarily to clean the raw material may exert a cleaning effect. Thus, blanching or scalding serves the additional purpose of cleaning the food, in addition to its primary objectives. The same applies to the water spray to cool foods after blanching.



Model HC MAGNUWASHER unit, used for washing mechanically harvested tomatoes as they are received at the plant. One of the chief advantages of this machine, is that the unit uses only 30 to 35 gallons per minute of water. The washing is done by means of soft flange rubber disks. Capacity is 25 to 35 tons per hour. (Courtesty Magnuson Engineers, Inc.)

Size Grading

Many products are put over a series of screens having holes of different diameters. For products like green beans a series of parallel bars with varying distances between them are used. Some machines revolve and others vibrate. Each product has certain size grading procedures that have been proven to give most satisfactory results. Larger round units may be put in a long narrow trough in the bottom of which are moving rollers, ropes or cables close together at one end and apart at the other end. The small units pass through first and the larger ones toward the open end.

Inspecting

All products must be inspected before they go into the cans. Modern machines are very efficient but personal inspection is still needed for proper assurance of freedom from imperfections. This is usually done by passing the washed produce over an inspection belt. This should be designed so that the inspectors can sit comfortably close to and facing the belt. Both hands should be free to use easily. Special attention should be given to proper lighting. It should be ample but diffused rather than glaring and should be so placed and shaded that the light does not shine in the workers' eyes.

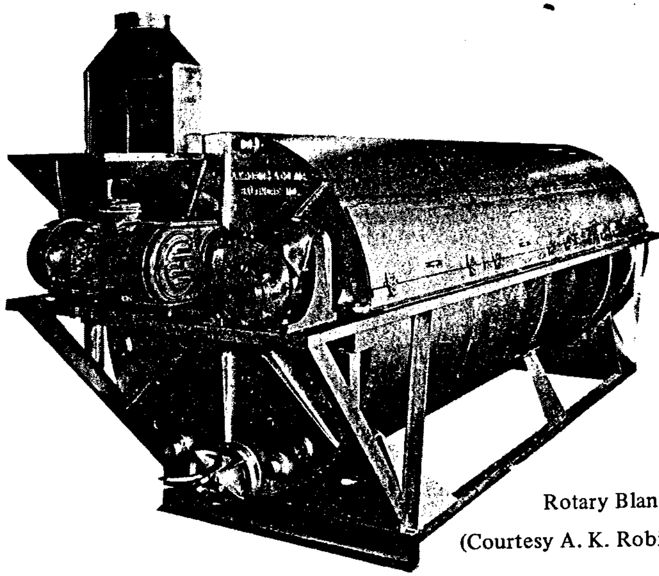
Blanching

Blanching is an operation in which a raw food material is immersed in water at 190°–210° F or exposed to live steam. Water temperature must be well controlled at a desirable level.

The objectives sought in blanching are not always the same but vary according to the maturity and type of vegetable used. Blanching of a given vegetable or fruit is done for one or more of the following reasons:

(a) Inhibition of enzymatic action. Natural product enzymes are inactivated and thus oxidative and other type chemical reactions are also inhibited, which contributes to higher product quality and nutritive value by avoiding undesirable changes in natural color and flavor, as well as reduction in the content of certain vitamins.

(b) Expelling of respiratory gases. Raw fruits and vegetables contain intracellular gases, of composition similar to that of air but somewhat higher than air in oxygen and carbon dioxide content. The release of gases prevents strain on the can seams during heat processing and favors development of a higher vacuum in the finished product. Another desirable effect is a reduction in internal can corrosion by reducing oxygen content of can headspace gases. Headspace oxygen



Rotary Blancher

(Courtesy A. K. Robins & Co., Inc.)

acts as a depolarizer in electrochemical corrosion reactions, thus increasing rate of corrosion.

(c) Softening of food. Product becomes easier to fill in container, and higher drained weights are obtained.

(d) Facilitating preliminary operations. Peeling, dicing, cutting, and other preparatory steps are accomplished more easily and efficiently.

(e) Setting the natural color of certain products.

(f) Removing raw flavors from food.

(g) Added cleaning measure.

Blanching is usually accomplished in equipment especially designed for individual products. The equipment must be so designed as to make it possible to subject the raw materials to a particular temperature range for the proper period of time. The shortest blanching time that accomplishes the desired objectives usually gives the best product. Many vegetables and some fruits are blanched.

Continuous hot water blanchers are usually of the following two types:

(a) Immersion or conveyor type employing either screw or chain conveyors by which the product is moved through a tank of hot water.

(b) Hydraulic type, where the product is conveyed in hot water through numerous lengths of pipe by a circulating pump and aid of steam jets.

Continuous steam type blanchers are mechanically more complex than are the hot water types. They continuously move the product through a tank containing live steam by use of a chain or belt conveyor.

The main disadvantage of hot water blanching is the large volume of water needed and its direct contact with the product. That results in some leaching of water soluble food constituents. Some of these are vitamins and minerals of importance in human nutrition. Results of research on several specific nutrients indicate a wide variability in nutrient losses caused by either hot water or steam blanching.

The leaching of water soluble substances also results in increased BOD of liquid effluents discharged from processing plants. This problem becomes extremely serious to food processors when the full meaning of the Water Pollution Control Act and subsequent regulations is closely analyzed. By July 1, 1977, the effluent limitations will require the application of the best practicable control technology currently available. By July 1, 1983, the effluent limitations will require applications of the best available technology economically achievable. Based upon the actions already taken by the Environmental Protection Agency (EPA), it can be anticipated that the effluent limitations for the canning and freezing industries may be set as best industry practice for 1977, and at zero discharge or something approaching zero discharge for 1983. There is the proviso that the EPA Administrator may modify the effluent limitations for any one plant if it is demonstrated that the effluent treatment represents the maximum use of technology within the economic capability of the owner or operator.

There is obvious need for modifying processing operations so as to reduce and whenever possible eliminate the amount of pollution generated. In processing of vegetables the operation that generates the most pollutants is blanching, on the average being over 40% of the total plant effluent BOD.

Hot gas blanching has been demonstrated as a means of reducing volume of waste water effluent from a blancher to less than one percent of that experienced with steam or hot water blanching. In pilot plant studies this has been found to apply to several commercially important vegetables, with the exclusion of cob corn or beets. In hot gas blanching, vegetables are heated by means of combustion of flue gases from a gas burner. The hot flue gases are recirculated upwards through the vegetables, which are conveyed through the blancher between two wire mesh belt conveyors. Steam is added to the recirculating flue gases to increase the relative humitity and minimize partial drying which would otherwise result in weight losses. The steam is also thought to facilitate heat transfer.

The data obtained indicate that hot gas blanched vegetables have quality well within the range of commercial acceptability. The overall results from studies on nutrient retention show no significant difference due to type of blanching received by the vegetable samples investigated. It is reported that hot-gas blanched spinach and peas show higher retention of ascorbic acid (vitamin C) than either hot water or steam blanching. Product weight loss with hot gas blanching has been found to be higher for many of the vegetables.

Research on hot gas blanching is being conducted by National Canners Association, where the original concept was developed, and at the University of Wisconsin. Hot gas blanching is still at the developmental stage for commercial application.

Where the blanched food product is washed prior to filling, potable water should be used.

Peeling

Steam Peelers. For steam peeling, products are exposed to steam under pressure in a fully insulated retort which revolves slowly, mixing the vegetables while rotating. Steam requirements are held to a minimum. Once the vegetables are steamed, they are discharged into the hopper below the retort where they are conveyed over rubber-coated rollers running at different speeds. This causes the vegetables to gyrate as they are pushed along the rollers by mean of mechanical fingers. Water from high pressure jets immediately above the rollers knocks the skins off as the product passes along the rollers. Skins drop into a hopper below the rollers while the peeled product is discharged onto a conveyer for inspection and further processing.

Abrasive Peelers. A tumbling action is utilized in abrasive peelers so that all surfaces of the vegetables undergoing peeling are exposed to a rubbing action against an abrasive surface, thus loosening the peel which is removed by water sprays. Some machines can be fitted with cylinder brushes which are interchangeable with the abrasive rollers. These brushes can be used for washing and, in some instances, will provide the only peeling necessary for thin-skinned vegetables, such as new potatoes. A combination of abrasive rolls and brushes is also an effective peeling medium for many products. In a number of operations, it is used following a steam or lye treatment.

Mechanical Peelers. Mechanical peelers are used especially with fruits. The equipment is especially designed for each application. Examples are apples and pears.

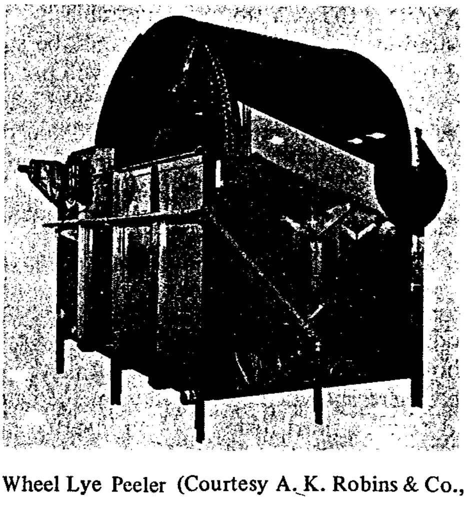
Flame Peelers. Used almost exclusively for pimientos. A description of flame peeling is included with canning procedure for that product.

Lye Peelers. The active agent in lye peeling is a water solution of caustic soda. Caustic soda, chemically sodium hydroxide, is often referred to as lye. It is one of the strongest commonly available alkali materials.

For peeling of root crops it is recommended that caustic soda alone be used. Extensive laboratory testing of additives with caustic soda such as soda ash, orthosilicate, and wetting agent has shown little advantage to be gained by the use of these materials. Some small benefit may be gained by using soda ash or wetting agent with respect to a smoother peel on root crops. It is felt, however, that the results obtained do not justify the extra cost. For peeling of fruits such as peaches, pears, apricots, etc., wetting agent has shown some increase in efficiency.

A lye peeling operation requires a generous water supply, caustic soda, and a source of heat. Apparatus for continuous lye peeling is now sold by food machinery manufacturers as a standard item. The use of copper, bronze, brass, aluminum, lead, zinc, and tin for fittings, cocks, valves and other accessories must be avoided because they are attacked by caustic soda.

A preliminary wash of the raw produce is very desirable. This greatly reduces contamination of the lye bath with dirt, weeds, and other foreign material.



Ferris Wheel Lye Peeler (Courtesy A. K. Robins & Co., Inc.)

To condition the skin of exceptionally tough vegetables such as storage beets the product is preheated prior to the lye treatment. The requirements for certain types of processing make a slight precook necessary. A blancher will reduce the heat consumption of the bath by raising the temperature of the produce charged. This step is strictly optional for most operations, and indeed is undesirable for certain types of potato peeling.

The lye peeler is essentially a heated tank for holding a solution of caustic soda, with means provided for passing the produce through this tank at a controlled rate. Two main types of peelers are used. One is the rotary or ferris wheel type and the other is known as the roto-screw peeler.

The rotary or ferris wheel type peeler consists of a perforated drum equipped with angular vanes around the periphery. The lower portions of the drum assembly is surrounded by a shell-like container or tank used to hold the lye treating solution. Steam coils or other means are provided to control the temperature of the operation. As the drum rotates, the raw produce is trapped by the advancing vanes and carried through the hot treating solution. This apparatus has the distinct advantage of requiring comparatively little floor space.

A typical roto-screw type peeler consists of a long, narrow, shallow vat-like tank. It is equipped with a continuous link belt conveyor, to which are fixed cross members similar to that of a typical drag conveyor. The movement of these cross members or flights propels the produce through the lye bath.

After the lye treatment, the vegetables must be subject to a water wash with pressure sprays to remove the lye-disintegrated peel. The wash is second only to the lye bath as the critical part of the lye peeling process. In general the washer is a revolving drum with a corrugated inner surface and equipped with water sprays on its axis. Means are provided for moving the produce through the washer. Water pressure in the sprays may be from 40 to 100 psi. or more, preferably of the order of 80 to 100 psi. for rotary washers. The design of the nozzles is critical because the water must loosen the soft gelatinous tissue and yet not cut the produce. Corrugations are built into the rotary washer to tumble the produce and to effect a rubbing action to help remove the skin from the vegetables.

The washing operation for most root crops should be such that a large mass of produce is retained in the washer at all times. This will provide a good tumbling, rubbing action which materially aids the skin removal and leads to a greater water economy. Properly designed and operated washers will yield produce that is clean, smooth and entirely free of caustic. Sometimes an acid dip is used following washing.

Manual trimming is necessary for removing major defects of the peeled and washed vegetables.

Cleaning the Cans

The sanitary codes of most States require that cans be washed before being filled. The practice should be universal as a bright can does not necessarily mean a thoroughly clean one. There should be three steps in the can cleaning operation. First, the cans should travel a short distance in an inverted position, second they should be flushed with a relatively large volume of water under good pressure, and third they should again travel a short distance in an inverted position for the purpose of draining excess of water. Satisfactory can washers are available from manufacturers of canning machinery. Effective can washing eliminates microorganisms which otherwise would contribute to the total microbiological product load.

Filling

Accurate and uniform filling of the food is necessary in order:

(1) To maintain a uniform headspace.
(2) To insure that the consistency of the pack remains uniform.
(3) To maintain a constant weight of product.

The term "filling" includes the addition of liquids such as brine, syrup, gravy stock, etc.

The amount of headspace in the can is very important. If it is too small, the can ends will bulge thus rendering the can unsuitable for sale. There is also insufficient space for accumulation of hydrogen gas (which is produced by certain canned foods) and the can ends will "dome". In addition, over filling can result in understerilization of the can.

Conversely, too large a headspace results in under-weight net contents of can which is illegal. Also, excessive headspace results in a relatively large amount of air being entrapped in the can. This accelerates product deterioration and can corrosion during storage.

Filling may be done either by hand or machine. Delicate products such as asparagus, broccoli, and soft fruits are filled by hand and the fill-in-weight is controlled by use of a small counterpoised weighing scale.

The simplest products to fill mechanically are liquids and semi-solids, such as syrup, brine, fruit juices, jam, soup, etc.

The ideal filling machine should fulfill the following functions:

(1) The quantity filled must be uniform and accurately measured.

(2) There must be no spilling or drip, even when running at high speed.

(3) A "no can, no fill" device should be incorporated.

(4) Changing from one can size or quantity of fill to another one should be a simple operation.

(5) The filler should be capable of handling a wide range of products.

(6) There should be no dead spaces in the filler where dirt and debris can accumulate and provide an opportunity for microorganisms to multiply.

(7) All surfaces in contact with food should be made of non-corrosive materials such as stainless steel.

The headspace, and consequently the fill-in-weight, for liquid products can be adjusted automatically:

(1) By filling the cans to the top and by inclining them on the conveyor at a predetermined angle thus allowing the surplus liquid to escape.

(2) By displacing a given amount of liquid with a plunger.

(3) By filling the can from a chamber of a predetermined volume.

The fill-in-weight for semi-liquid and pasty materials is automatically controlled in many cases by forcing the product into the can from a chamber of predetermined volume by use of a plunger. With a few products, however, the plunger is not needed.

Automatically controlling the fill-in-weight for solid products is often done by filling from hoppers of predetermined volume or by filling from the hoppers into revolving pockets which then deposit the product into the cans. Most of these fillers also have devices by which brine or syrup is added to the cans along with the solid product.

An important consideration to take into account at all stages of the filling operation is that the filling of containers, either mechanically or by hand, should be controlled so as to ensure that the filling requirements specified in the scheduled sterilization process are met.

Vacuum in Canned Foods

The term "vacuum" as used in the canned foods industry is an indication of the amount of air left in the headspace of food cans. Not all the air is exhausted from canned foods.

The food industry measures vacuum in terms of inches of mercury (in. Hg). 30 in. Hg indicates total vacuum, while 0 in. Hg shows no vacuum at all. A vacuum of 10 in. Hg means that one-third of the air has been removed from the headspace of the can. Some canned foods are packed with low vacuums, in the range from two to six in. Hg. With most canned foods it is recommended to have vacuums between 10 and 20 in. Hg. For some foods it is desirable to have higher vacuums of up to 26 in. Hg.

There are several reasons for obtaining vacuum in canned foods. These include: the maintenance of can ends in a concave position during normal storage; the reduction of oxygen; and the prevention of permanent distortion of can ends during thermal processing.

The technique employed from the very beginning of canning has been such that a vacuum has resulted. Bacterial spoilage usually results in gas formation which causes bulging of the can ends. Consequently, any distortion of the end from the normal concave shape is taken as an indication of spoilage by the industry and by the consumer.

A low oxygen content in canned foods is desirable to minimize adverse chemical changes in the product, such as oxidation of fats or vitamins, to prevent discoloration in some products, and also to reduce internal corrosion of the can.

During thermal processing there is considerable expansion of the can contents. This may result in permanent distortion of the ends, particularly in larger can sizes, unless provision is made for this expansion without the development of undue pressure within the can. This is accomplished by providing adequate headspace under vacuum. Also, in some instances counterpressure on the exterior of the can during cooling is necessary. This latter procedure is known as "pressure cooling".

The mechanical gauge in common use for measuring vacuum is the Bourdon tube type. This gauge is basically the same for pressure or for vacuum. The Bourdon tube gauge has been adapted for measuring can vacuum by equipping it with a hollow puncture tip surrounded by a rubber sealing ferrule.

Atmospheric pressure varies from day to day and also decreases with an increase in altitude slightly more than 1 inch for each 1,000 feet. In this connection it is interesting to note that a can having 10 inches true vacuum at sea level would only have approximately 5 inches in Denver and a slight pressure on top of Pikes Peak. Conversely the vacuum would increase in cans closed at high elevation and removed to lower altitudes.

Exhausting and Vacuum Closing

The exhausting of containers for the removal of air should be controlled so as to meet the conditions for which the process was designed.

Vacuum in canned foods may be obtained by pre-heating foods prior to closing. In producing vacuum by this means, the product may be heated prior to filling, or after filling, or it may be heated both before and after filling. Heat in this case is employed to expand the product, to expand and drive out the occluded and dissolved gases in the product and to rarify the air in the headspace before closure. The length of heating and the final temperature attained before closure have a very important relationship to the ultimate vacuum in the can.

Heating may be accomplished by passing the filled can through a steam or hot water exhaust box. It is common to refer to exhaust box treatment as "thermal exhaust" and to preheating before filling as "hot fill". Exhaust boxes are generally best adapted for canned foods that can readily be heated, such as brine-and syrup-packed fruits and vegetables. The major disadvantages of exhaust boxes are in their bulkiness and their large steam requirements.

In mechanical vacuum closure by high speed vacuum closing machines the filled cans while cold or at a rather low temperature are passed into a clincher which loosely clinches the covers without forming an air-tight seal. The cans are then transferred through a suitable valve into a vacuum chamber, subjected to vacuum for an instant while in the vacuum chamber, sealed, and then ejected through another valve. Vacuums drawn on the machine while the cans are in the vacuum chamber may be varied over a wide range, depending mainly on the desired final vacuum in the can and also on the temperature of the liquid contents. This method of exhausting air from canned foods subjects the contents to a vacuum for a rather short interval of time before closure. Therefore, the air is withdrawn mainly from the headspace, and only partially from the product itself, and proper adjustment of the headspace is necessary for proper performance.

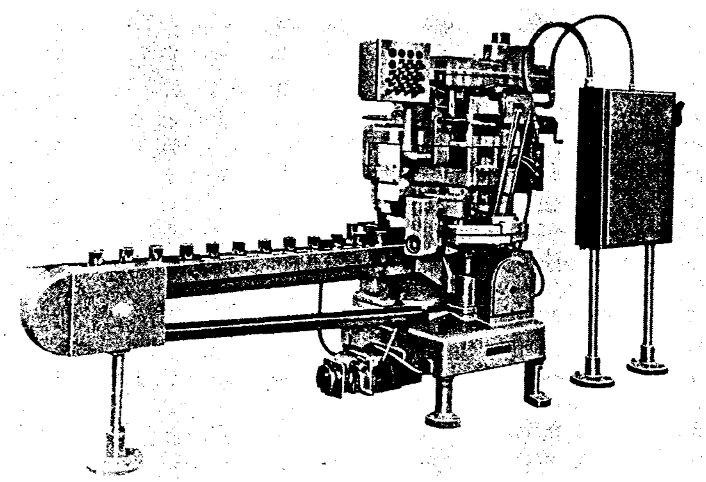
There is one difficulty with high speed vacuum closures in connection with some brine- and syrup-packed foods. Since the vacuum is applied over a very short interval of time, "flashing" of the liquid contents from the can will occur when there is an appreciable amount of dissolved or occluded air in the product and in the void spaces in the product. This happens because air escaping rapidly from the contents of the can will often carry liquid with it at the same time. This is especially true with syrup-packed fruits such as peach and pear halves, sliced and diced fruits, and pitted cherries, and it results in some syrup loss. This difficulty has been overcome by employing a prevacuumizing step prior to vacuum closure. For canned fruits, particularly, prevacuumizing syrupers have been developed which operate as follows: Freshly prepared fruit is filled into cans and passed into a vacuum chamber which draws a vacuum in the range of 20-27 inches on the filled can, exhausting most of the air surrounding the product and some from within the product itself. While still under vacuum, syrup is added to the can to a predetermined height and the filled can is then transferred to the open atmosphere. With this preliminary air exhausting step, the filled cans can be sealed in a vacuum closing machine with little variation in the final vacuum from can to can and with little or no loss of liquid content.

Another method for producing vacuum in canned foods is based on the injection of live steam into the can or glass container headspace at the time of closure. If live steam is properly injected into the headspace volume of a container, it will replace essentially all of the air with steam. Then, providing the cover is immediately applied to the can and seamed, vacuum will be formed when the steam condenses. This, therefore, provides a simple, inexpensive method of exhausting the headspace volume of its air.

The underlying principle of ali "Steam-Vac" or "Steam-Flow" closures is to replace the air in the headspace with live steam as fully as possible at the moment of closure. During this operation the product is not heated, except slightly at the top surface, and little or no accluded air within the product or in the void spaces beneath the top surface is removed by the action of the steam. Consequently, to obtain good vacuum the product must not contain much occluded air at the time of closure, and an adequate and controlled headspace must be provided.

Preheating of the product prior to filling, or even after filling followed by "Steam-Vac" closure has been practiced for some products which contain large amounts of occluded air and other gases.

Low vacuum in canned foods may be the result of poor exhausting, faulty closing, or leakage through the can seam after closure.



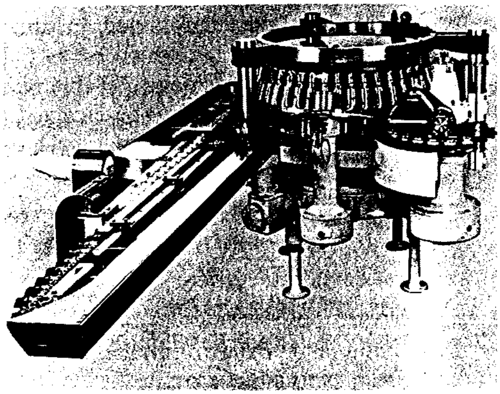
Angelus Model 61H Closing Machine
(Courtesty Angelus Sanitary Can Machine Co.)

Can Closing

Good quality tinplate, adequate sealing compound, and an efficient can closing machine combine to produce a strong and hermetic double seam that will addequately protect the canned food during sterilization, cooling, and storage.

Can sealing machines today operate at speeds of several hundred cans per minute. Considerable progress has also been made in automatic closing of glass jars for canned foods. Glass container closing machines are, however, somewhat slower than can closing machines because of the fragility of glass.

The use of vacuum can closing machines is becoming more general. These sealers will create a vacuum in the can either by using mechanical means of extracting the air, or by jets of steam directed into and around the can. The steam partially replaces the can headspace gases, and lid is applied while steam is filling the headspace. Thus water vapor is trapped in the can. This water vapor condenses when the can cools down after sterilization, thus creating a vacuum. This type of can closing machine is known as "Steam-Flow" or "Steam-Vac" sealer.



Anchor 45 Head Rotary Steam Vacuum Capper for Glass Containers capable of sealing speeds to 2,000 jars per minute. Presently in use by the baby food industry at line speeds ranging from 1,000 to 1,300 jars per min.

(Courtesy Anchor Hocking Corporation)

The use of a vacuum can closing machine in the canning line eliminates the need for exhausting, and therefore saves processing space.

Container Coding

Can and glass container coding and the frequency of code changes are extremely important to food processors.

Container codes should give the following information:

1. Plant where packed-if more than one plant
2. Product and style of pack
3. Day of pack
4. Hour of pack
5. Line on which product was packed

Important benefits come from a coding system if properly tied in with production and shipping records.

If a problem should occur such as: under-processing with a potential public health hazard, spoilage in the warehouse or in distribution, discovery of extraneous contamination, consumer complaints and alleged illnesses, or seizure by a regulatory agency with subsequent forced or voluntary recall, the investigation and/or recall can be confined to one day's pack, one hour of production, or to one line in the plant. Otherwise, the problem may result in restraint from sale of all or a sizeable portion of a plant's production.

A batch code may consist of a retort load or the production during a period of time, preferably not more than 2½ hours. Some canners have found it convenient to change die codes during the "break" period.

With relation to low-acid foods, each container should be marked with an identifying code which should be permanently visible to the naked eye. Where the container does not permit the code to be embossed or inked, the label may be legibly perforated or otherwise marked, provided that the label is securely affixed to the product container. The identification should identify in code the establishment where packed, the product contained in the package, the year packed, the day packed, and the period during which packed. The packing period code should be changed with sufficient frequency to enable ready identification of lots during their sale and distribution. Codes may be changed on the basis of the following: Intervals of every 4 to 5 hours; personnel shift changes; or batches, provided the containers comprising such batch do not extend over a period of more than one personnel shift.

STERILIZATION

In 1973, the U.S. Food and Drug Administration promulgated Good Manufacturing Practices (GMP) pertaining specifically to low-acid foods. These regulations are entitled "Thermally Processed Low-Acid Foods Packaged in Hermetically Sealed Containers." Included in this book on pages thru there is a section entitled "Low-Acid Canned Food GMP Regulations." That section explains in general the requirements of the above mentioned FDA regulations. It is outside the scope of this book to include all the details which are included in the GMP regulations. It is very important that canners of low-acid foods become thoroughly acquainted with the GMP regulations, and that they make sure that their plant equipment and processing procedures conform in detail with those regulations. These GMP regulations were published on January 24, 1973 on pages 2398-2410 in the *Federal Register* as Part 128b, Chapter 1, Title 21 of the Code of Federal Regulations. They are also published in *The Almanac of the Canning, Freezing, Preserving Industries,* published by E.E. Judge & Sons, Inc., at Westminster, Md. 21157.

Furthermore, federal and state regulations pertaining to canned foods may be modified from time to time. Therefore, canners must always consult and comply with latest regulations that affect their operations.

The objective of the sterilization process is to produce a condition of "commercial sterility" in canned foods. "Commercial sterility" of foods means the condition achieved by application of heat which renders food free of viable forms of microorganisms having public health significance, as well as any microorganisms of non-health significance capable of reproducing in the food under normal non-refrigerated conditions of storage and distribution. The recommended sterilization processes are not designed to kill all microorganisms in canned foods. In other words, canned foods are "commercially sterile," but not bacteriologically sterile.

In canned food sterilization the main concern of the canning industry is to prevent the growth of *Clostridium botulinum,* the food poisoning bacterium capable of producing a highly lethal toxin.

Cl. botulinum is a highly heat resistant bacterium. A sterilization process that assures the destruction of *Cl. botulinum* also kills all other microorganisms capable of producing canned food spoilage under normal conditions of canned food handling and storage.

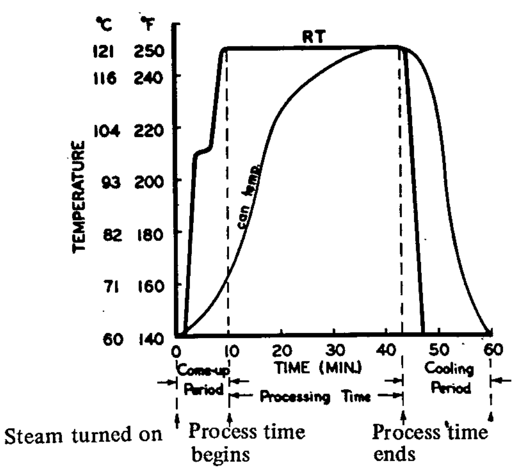
For many years laboratories connected with the canning industry and other laboratories have devoted attention to *Clostridium botulinum.* A great amount of work has centered on heat-resistance studies, and processing recommendations for foods are based upon the results of this research. Concurrently a study was made of the growth necessities for *Clostridium botulinum* and it was found that the dividing line of acidity between products in which the organism would grow and those in which it would not grow was about pH 4.6. This level is considered inhibitory for the growth of the organism in a favorable medium. This is a most important observation because as a practical matter it means that, in general, products of pH levels higher than pH 4.6 must be processed under pressure at temperatures above 212° F in order to insure destruction of the spores, while products at pH 4.6 or lower may be safely processed at 212°F. The experience of the industry over a spread of many years has established the validity of this product classification.

"Commercial sterility" of equipment and containers used for aseptic processing and packaging of food means the condition achieved by application of heat, chemical sterilant(s), or other appropriate treatment which renders such equipment and containers free of viable forms of micro-organisms having any public health significance as well as any microorganisms of non-health significance capable of reproducing in the food under normal non-refrigerated conditions of storage and distribution.

STERILIZATION IN STILL RETORTS–CANS

The details of this most important operation in the successful canning of low-acid foods has been the subject of much research by laboratories connected with the canning industry. The National Canners Association has prepared a carefully worded statement which every canner should study. Because of its

HEAT PENETRATION CURVE FOR CAN AT COLD POINT AND RETORT TEMPERATURE



Typical heat penetration curve for canned foods showing retort temperature and temperature of food at slowest heating point within can. (RT is Retort Temperature; Can temp. is temperature of can contents at slowest heating point ("cold" point or "critical" point).

importance, we next reproduce the essential paragraphs of the Introduction to NCA Bulletin 26-L Tenth Edition "Processes For Low-Acid Canned Foods in Metal Containers."

IMPORTANCE OF PROPER EQUIPMENT AND PROCEDURE

Close supervision of the cook room and careful attention to details are essential to ensure sucessful processing; otherwise, irregularities may occur due to poor organization of the cook room, to carelessness, or to ignorance of safe practices.

In order to be certain that all cans secure the amount of heat treatment required to prevent spoilage, adequate venting of air from all parts of the retort, and careful control and recording of temperatures and times are essential. Processes for canned foods are determined by tests made with the cans in "pure" steam (free of air) at a definitely controlled and specified temperature. When these processes are applied in commercial practice identical conditions must be met. The suggestions under "Equipment" and "Procedure" are based on the results of careful studies to determine what type of equipment and procedure may be relied upon to give the required heat treatment under commercial conditions.

RETORTING EQUIPMENT

Type of Retort

The processes contained in this book are for cans processed in pure saturated steam (free from air) in discontinuous (bath type), nonagitating (still), vertical or horizontal retorts. For other types of processing equipment, the processes should be obtained from a laboratory connected with the canning industry. Procedures for processing glass containers under water with superimposed air pressure are given in NCA Bulletin 30-L.

Retort Equipment and Operation

The proper installation and operation of retorts is essential for the correct use of the processes given in this book. The following information provides a guide for the minimum requirements necessary for installing and operating retorts for the pressure processing of low acid foods.

(1) Steam Pressure. The steam pressure in the line to the retorts should be not less than 90 psi at all times during operation. Lower pressures will result in unnecessarily long retort come-up times. Higher steam pressures are necessary for shorter come-up times and for larger retorts.

(2) Steam Header. The supply line delivering steam to a group of retorts should be large enough to provide sufficient steam for the greatest number of retorts that may be brought to retort temperature simultaneously. The minimum suggested pipe sizes are given in the following table:

Number of Retorts Brought Up Simultaneously	Header Pipe Size: Vertical & Horizontal Retorts Less than 15' Long	Header Pipe Size: Horizontal Retorts Over 15' Long
1	2 inches	2 to 2½ inches
2	2½ inches	3 to 3½ inches
3	3 inches	3½ to 4 inches
4	3½ inches	4 to 5 inches

(3) Steam Inlet. The steam inlet to each individual retort must be large enough to provide sufficient steam for venting the retort in a reasonable length of time. It may enter either the top or the bottom of the retort, but must enter the end or side opposite the vent.

(4) Steam Controller. Each retort should be equipped with an automatic steam controller to accurately maintain the specified retort temperature within $\pm 1°$ F. This may be a self-actuated or air-actuated (air-to-open) type. It may be smaller than the steam inlet pipe if a by-pass is used during the coming-up period.

(5) Steam Spreader. Steam spreaders are perforated continuations of the steam line inside the retort and should not be larger than the steam inlet line.

Spreaders are necessary in all installations except for vertical retorts vented at the bottom, where the steam enters at the top of the retort. With horizontal retorts the perforated pipe should extend along the bottom for the entire length of the retort, and the perforations should be along the top 90° of this pipe. For the best distribution, the steam should enter at the middle of the bottom of the retort. For retorts over 20 feet long, it is desirable to have two inlets connected to the spreader, located one-quarter of the distance from each end. In vertical retorts the perforated pipe is usually in the form of a cross with the perforations along the top or sides of the pipe. To insure proper distribution of steam, the number of perforations should be such that the total cross sectional area of the perforations is equal to *one and one-half to two times* the cross sectional area of the steam inlet line. The following table may be used as a guide:

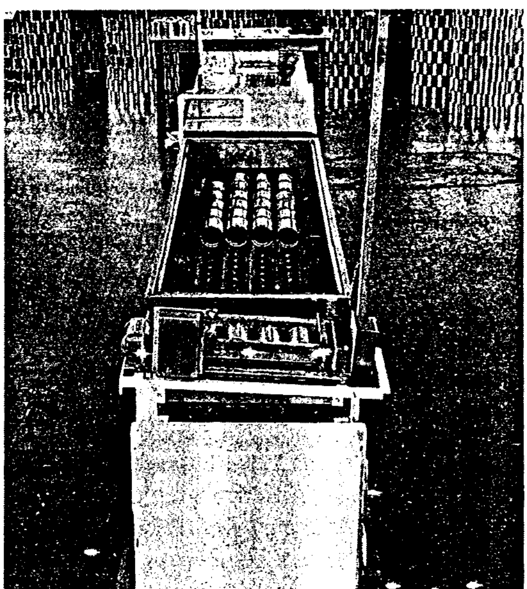
Size Holes (inches)	Number of Holes in Steam Spreaders for Steam Inlet Pipe Sizes: 1 inch pipe	1¼ inch pipe	1½ inch pipe	2 inch pipe	2½ inch pipe
3/16	47–62	81–108	111–148	183–244	260–346
1/4	27–36	45–60	63–84	102–137	147–196
3/8	–	–	28–37	45–60	66–88
1/2	–	–	15–20	26–36	36–48

(6) Steam By-Pass. A steam by-pass for the control valve is desirable to make possible hand operation of the retort in the event of a failure of the control valve,

and also to admit steam rapidly during the coming-up period when steam is usually demanded in larger quantities than the control valve is capable of handling. This is particularly true if a smaller control valve is used. This steam by-pass should be the same size as the pipe bringing the steam to the retort. FOR SAFETY THE OPERATOR MUST NOT LEAVE THE RETORT WHILE THE BYPASS IS OPEN.

(7) Safety Valve. Safety valves of adequate capacity are necessary to prevent excess pressure in retorts. These should comply with local safety codes or the A.S.M.E. code for unfired pressure vessels. Since the relieving capacity of a given size safety valve varies as to the manufacturer, no specification as to the required size can be given. Such specifications should be worked out with the manufacturer for the specific operating conditions.

(8) Vent. Vents are *large* valve-controlled openings in retorts, used for elimination of air during the venting period. They should be installed in such a way that all the air can be removed from the retort before timing of the process is started. Vents must be controlled by gate or plug cock type valves or other adequate valves, which must be fully open to permit rapid discharge of air from the retort during the venting period.. The vents and all external lines, manifolds, etc., should be short and as free as possible from bends and other conditions which might retard rapid discharge of air. Such lines should discharge to the atmosphere as close to the retort as possible. THEY MUST NOT BE CONNECTED DIRECTLY TO THE DRAIN SYSTEM. If the overflow is used as a vent, there must be an atmospheric break in the line before it connects to the drain. This is required to



Spin Cooker-Cooler
(Courtesy Instituto de Tecnologia de Alimentos, Campinas, S.P., Brazil)

prevent back pressure during venting and to meet plumbing codes. *The vent must be located in the extreme opposite end or side of the retort from that through which the steam is admitted.*

Timing of the process shall not begin until the retort has been properly vented and the processing temperature has been reached.

(9) Vent Manifold. The best air removal is accomplished by venting directly to the atmosphere from the gate or plug cock valve controlling the vent. However, it is often desirable to remove the steam vapor from the retort room by connecting the vent pipes to a suitably sized manifold or manifold header. A *manifold* connects several vent pipes from a single retort and is controlled by a gate or plug cock type valve. The manifold must be of a size so that the cross sectional area of the pipe is larger than the total cross sectional area of all connecting vents and be at least one pipe size large than the steam inlet. A *manifold header* connects vents or manifolds from several retorts and leads to the atmosphere within as short a distance as practical and with as few bends as possible. It is *not* controlled by a valve. These extensions of the vents should be as short as possible and discharge to the atmosphere. The discharge must not be directly connected to a drain without an atmospheric break in the line. The manifold header must be sized so that the cross sectional area is at least equal to the total cross sectional area of all connecting manifold pipes from all retorts venting simultaneously. If the header is of excessive length, it should be increased at least one pipe size.

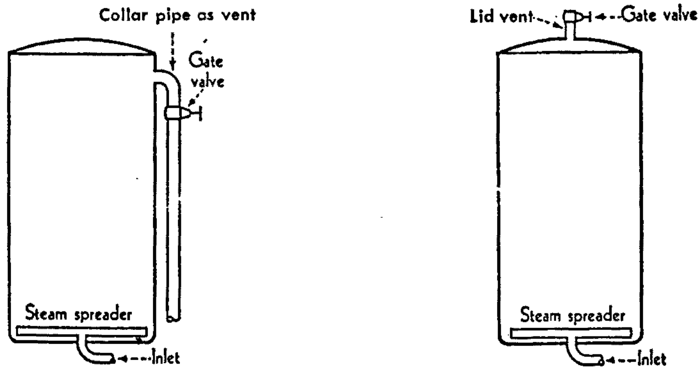
(10) Minimum Retort Venting Requirements. No single venting method is entirely applicable to all retorts. The choice of a satisfactory method is dependent upon size, shape, and equipment of retorts, as well as upon quantity and pressure of steam available, method of stacking cans in the retort, length of coming-up time desired, resistance to outward flow of air from the retort, etc. TO ASSURE COMPLETE AIR REMOVAL DURING VENTING, IT IS NECESSARY TO MEET *BOTH TIME AND TEMPERATURE* REQUIREMENTS FOR A PARTICULAR RETORT INSTALLATION.

Some typical installations and operating procedures are given in the following sections and diagrams. These sections detail the *minimum* requirements necessary to vent adequately several typical retort hook-ups. There are other possible installation and operating procedures which will result in adequate air removal. These variations should be analyzed by qualified individuals who should specify venting schedules to provide adequate air removal.

In order to decrease the come-up time of a given retort hook-up, the incoming steam pressure, inlet steam lines, steam spreaders, and vent lines must be increased over the minimum shown, with the vent openings always being at least one pipe size larger than the inlet steam line.

In the following detailed operating procedures the venting method given assumes that the vent valve, steam valve, and steam by-pass, if used, are fully opened and that the water and air valves are closed:

VERTICAL RETORTS VENTING THROUGH SINGLE TOP VENT



Minimum Specifications:

Steam: At least 90 psi steam pressure through a 1" steam inlet and spreader.

Vent: Venting is done through a 1¼" pipe opening in the collar or lid controlled by a 1¼" gate or plug cock valve, and with not more than 6' of 1¼" pipe beyond the valve to the atmosphere or any adequately sized manifold header.

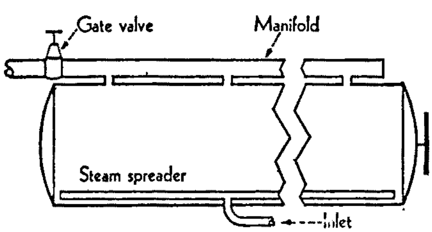
Venting Method: The vent valve should be wide open for at least the following minimum time *and* temperature:

3 min. *and* 220° F.
or 4 min. *and* 218° F.
or 5 min. *and* 215° F.

When perforated *divider plates* are used between each layer of cans, the vent valve should be wide open for at least

5 min. *and* 225° F.

HORIZONTAL RETORTS–VENTING THROUGH MULTIPLE VENTS AND A MANIFOLD



Minimum Specifications:

	Retort Length, in Feet		
	Under 15	15–20	20–30
Steam Pressure, psi	90	120	120
Steam Inlet, inch	1	2	2½
Vent Pipe, inch	1	1	1
Vent Manifold, inch	1¼	2½	3

Steam: The steam spreader should be the same size as the inlet and run the entire length of the bottom center of the retort with the steam entering at the middle of the retort. For retorts over 30 feet long, it is desirable to have two inlets for steam connected to the spreader, located one-quarter of the distance from each end. Retorts over 20' long may need two parallel spreaders.

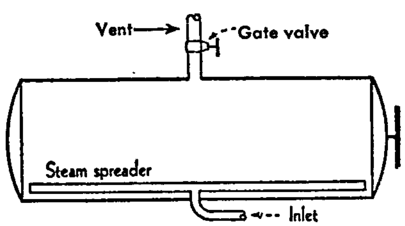
Vent: There should be vent openings not over 2' from each end and additional vents not over 5' apart along the top center of the retort. These vents are connected to a manifold equipped with a gate valve or plug cock valve of the same size. The manifold and valve must be sized so the cross sectional area is at least equal to the cross sectional area of all the vents from the retort and also one pipe size larger than the steam inlet. This may lead to the atmosphere or be connected to an adequately sized manifold header.

Venting Method: The manifold vent valve should be wide open for at least the following minimum time *and* temperature:

6 min. *and* 225° F.
or 8 min. *and* 220° F.

When perforated *divider plates* are used between each layer of cans, consult a laboratory connected with the canning industry for the proper venting time and temperature.

HORIZONTAL RETORTS VENTING THROUGH A SINGLE TOP VENT



Minimum Specifications:

Steam: At least 90 psi steam pressure through a 1" steam inlet and spreader.

Vent: Venting is done through a single 1¼" vent located at top center of the retort, equipped with a 1¼" gate or plug cock valve and with not over 6' of 1¼" pipe beyond the valve to the atmosphere, or to an adequately sized manifold header.

Venting Method: The vent valve should be wide open for at least the following minimum time *and* temperature:

5 min. *and* 220° F.
or 6 min. *and* 218° F.
or 7 min. *and* 215° F.

Retort loading systems employing divider plates between layers of cans generally require increased venting schedules. These divider plates should have the same perforations (1" holes on 2" centers) or their equivalent, as used for crate bottoms. A laboratory connected with the canning industry should be consulted for specific details in establishing an adequate venting schedule for this type of equipment.

(11) Bleeders. DO NOT CONFUSE BLEEDERS WITH VENTS!

Bleeders are 1/8 to 1/4" petcocks used to remove any air entering the retort with the steam and to provide circulation of steam in the retort and past thermometer bulbs in wells. Horizontal retorts should have one bleeder within one foot of each end and additional bleeders not more than 8 feet apart along the top. A vertical retort should have one bleeder at the end opposite to that at which steam is admitted. Bleeders are necessary on all thermometer wells.

Bleeders MUST be open and emit steam continuously and freely during the entire process, including the coming-up time. All bleeders should be arranged in such a way that the operator can observe that steam is escaping during the process. In cases of top steam inlet and bottom venting, an adequately sized bleeder should be installed in the bottom of the retort to insure complete removal of condensate. Its discharge should be above the retort platform. Bleeders may be installed in the bottom of any retort to remove condensate.

(12) Drain. The drain should be large enough to permit the rapid removal of water after cooling. Only when steam is admitted at the top should the drain be used as a vent. In this case the drain line must be open to the atmosphere.

(13) Water Line. If containers are to be cooled in the retort, water inlet and supply line sizes and line pressure should be adequate to allow for rapid filling of the retort. Globe valves should be used on waterlines.

Water valves must be in good condition to insure that water does not enter the retort through a leaking valve and result in underprocessing. To prevent splashing of water with a resultant condensing of steam during pressure cooling, a small baffle may be placed directly above the bottom water inlet. This must be below the steam spreader.

(14) Air Line. If retorts are equipped with air for pressure cooling, a globe valve must be used on the air line. Air leakage into the retort during processing must be avoided since a-steam-air mixture will reduce the effectiveness of the process and result in under processing.

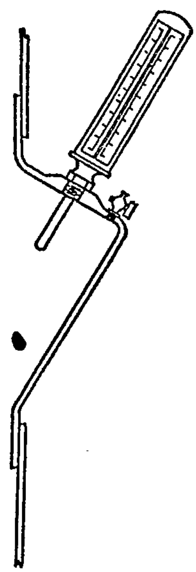
(15) Crate Supports (or Baffle Plates). Some type of bottom crate support should be provided in vertical retorts. Baffle plates should not be used in the

bottom of vertical retorts because they tend to direct the flow of steam around the load rather than up through it. The use of baffle plates in conjunction with perforated crate bottoms in vertical retorts has caused underprocessing due to cold spots or localized steam-air mixtures.

TEMPERATURE, PRESSURE, AND TIME MEASUREMENT EQUIPMENT

All control and indicating equipment, such as thermometers and pressure gauges should be maintained in a clean and workable condition. This equipment should also be placed on the retort with respect to light and position so that they can be read easily.

(1) Indicating Mercury-in-Glass Thermometer. Each retort must be equipped with at least one mercury-in-glass thermometer having a temperature range of not more than 100° F (170° F-270° F) on a scale at least 7" in length. The scale divisions should be no more than 2° F–preferably one 1° F.



Bulbs of indicating thermometers may be installed within the retort shell or in external wells attached to the retort. External wells or pipes should be connected to the retort through at least a 3/4" diameter opening, and be equipped with 1/16" or larger bleeders so located as to provide a full flow of steam past the entire length of the thermometer bulb. The bleeder must emit steam continuously and freely during the entire processing period.

Thermometers should be installed where they can be easily read and the glass kept clean. A metal guard may be installed if necessary to protect them from damage. They should not be installed in the lid of a retort as an abrupt jar may cause the mercury column to divide. A thermometer with a divided mercury column or that deviates more than 1° F from the standard should be replaced. Thermometers should be tested for accuracy against a known accurate standard thermometer upon installation and at least once a year thereafter or any time their accuracy is questioned. THE MERCURY THERMOMETER, NOT THE RECORDER CHART, MUST BE THE OFFICIAL INSTRUMENT FOR INDICATING THE PROCESSING TEMPERATURE. THE RECORDER READING CAN BE EASILY CHANGED BY ADJUSTMENT OF THE PEN.

(2) Recording Thermometer. It is extremely desirable to have a recording thermometer on each retort. Packers of low-acid foods are required by FDA regulations to do so. The chart from the recording thermometer provides a permanent record of time and temperature of each lot processed. The chart must be easily readable to 1° F, and the graduations should not exceed 2° F, within a range

of 10° F of the processing temperature. All charts should have a working scale of not less than 3". Packers of low-acid foods are required by FDA regulations to have charts with a working scale of not more than 50° F per inch within a range of 20° F. This recorder may be combined with the steam controller and be a recording-controlling instrument.

The bulb may be installed within the retort shell or in a thermometer well attached to the shell. The well should be capable of accommodating both the recorder bulb and a mercury-in-glass thermometer. This well must have a 1/8" or larger bleeder open at all times during the processing period. The recording thermometer must be adjusted to agree with an accurate mercury-in-glass thermometer.

(3) Pressure Gauges. Each retort should be equipped with a pressure gauge graduated in two pound divisions or less, having a range of 0 to 30 pounds. The minimum diameter of the dial should be 3½", and the gauge should preferably be of a type in which the operating mechanism is independent of the case. The gauge should be connected to the retort by means of a gauge siphon or goose neck to protect the gauge. Gauge should be no more than 4 inches higher than gooseneck. Pressure gauges should be tested against a standard gauge for accuracy upon installation and at least once a year thereafter, or at any time their accuracy is questioned.

(4) Process Timing. A large, easily read clock or accurate timing device with an alarm should be installed where it can be observed readily by the retort operators. Wrist or pocket watches are not adequate for timing processes. Processes should not be timed by observing the recording thermometer. Extreme care is required for process timing at higher retort temperatures. Even a process time slightly shorter than recommended will, at higher retort temperatures, drastically lower the lethality of the process.

CAN LOADING EQUIPMENT

(1) Crates, Baskets, Trays, and Dividers. Containers used to hold cans in retorts should preferably be of strap iron. Perforated containers are satisfactory as long as there are sufficient perforations to allow steam to flow adequately among the cans. Insufficiently perforated crate, basket, or truck bottoms, trays, or dividers should not be used since they lead to formation if low temperature areas in the baskets or trucks. When perforated metal is used for dividers or bottoms of baskets or trucks, the perforations should be approximately 1" holes on 2" centers or their equivalent (½" on 1" centers, ¾" on 1½" centers, 1½" on 2½" centers, or 1¾" on 3" centers). Baskets, crates, or dividers with less open space may not permit complete removal of air during minimum venting schedules. Inadequately perforated baskets or trucks can be corrected by placing wire mesh or expanded metal inside the bottom.

(2) Stacking of Cans. Cans should be so stacked as to permit the free circulation of steam throughout the retort load. If it is necessary to separate two lots in one crate or tray, fish net or other material of 1/2" or larger mesh should be

used. Do not use burlap sacks, boards, sugar sacks, towels, or other similar materials as dividers because they will interfere with steam circulation and cause under processing.

(3) Divider Systems. Retort loading systems employing divider plates between layers of cans generally require increased venting schedules. These divider plates should have the same perforations (1" holes on 2" centers) or their equivalent, as used for crate bottoms. A laboratory connected with the canning industry should be consulted for specific details in establishing an adequate venting schedule for this type of equipment.

PRESSURE COOLING

If the cans are to be cooled in the retort under pressure, equipment and procedures in addition to those described above will be necessary. For information, a laboratory connected with the canning industry should be consulted.

MAINTENANCE OF EQUIPMENT

Processing equipment should be maintained in a satisfactory operating condition at all times. Safety valves should be tested frequently. Instruments (gauges, thermometers, recorders) should be checked for accuracy upon installation and at least once a year or whenever their accuracy is questioned. Water valves and compressed air valves, especially the latter, should be checked frequently for leaks.

Before each operating season and after any extended idle period, the entire retort hook-up should be examined carefully; and each retort should be brought to processing temperature (without a load) to test for leaks, to check the vents, and to test the instruments and control equipment for proper operation and accurate recording. Never introduce water into an empty retort after testing until the pressure has been released.

COOK ROOM PROCEDURE

All cans should be so closed and processed that the ends will remain concave under normal commercial conditions of storage and distribution. To maintain concave ends, commercial experience has indicated that with products packed in brine without steam flow or mechanical vacuum closure, the average temperature (temperature of the contents of the can after thorough mixing) of the contents of each can at the time of closure should be at least 130°F. Cans of large diameter may require a much higher closing temperature to prevent distortion of the ends during processing. For many products a higher vacuum than that obtained from having an average closing temperature of 130° F will be necessary in order to maintain the canned product in good condition.

Coding

All containers should be coded by marks to identify the time of packing. The time period during which each code lot is packed should be as short as practicable. Strict adherence to this rule has proved to be good economy in the event that some irregularity occurs.

Special regulations apply to low-acid foods. In that instance, each hermetically sealed container should be marked with an identifying code which should be permanently visible to the naked eye. Where the container does not permit the code to be embossed or inked the label may be legibly perforated or otherwise marked, provided that the label is securely affixed to the container. The required identification should identify in code the establishment where packed, the product contained, the year and day packed, and the period during which packed. The packing period code should be changed with sufficient frequency to enable ready identification of lots during their sale and distribution. Codes may be changed on the basis of the following: Intervals of every 4 to 5 hours; personnel shift changes; or batches; provided the containers comprising such batch do not extend over a period of more than one personnel shift.

Process

The term "process" as used here means the application of heat to sealed containers for a definite time and at a definite temperature under specific conditions. The purpose for processing is to produce a commercially sterile product. This must be obtained with the least possible adverse effect on quality. If the number of organisms in the product is excessive, the processes listed might not be adequate to prevent spoilage. Therefore, it is essential that contamination be kept as low as possible.

Operation of Cook Room

In order to minimize the possibility of mistakes and reduce the danger of unprocessed or underprocessed cans reaching the warehouse, it is recommended that:

(1) Processes for all products being packed be posted in a conspicuous place near the retorts.

(2) All baskets, trucks, cars or crates containing unretorted material be plainly and conspicuously marked. If several products are being packed at the same time, each product should also be plainly indicated. For low-acid foods, the FDA Good Manufacturing Practices regulations require that "all retort baskets, trucks, cars, or crates containing unretorted food product, or some of the containers on the top of each basket shall be plainly and conspicously marked with a heat sensitive indicator, or by other effective means, which will visually indicate to thermal processing personnel whether or not each such unit has been retorted."

This requirement is intended to prevent an unretorted lot of cans from by-passing the retort and going directly from the closing machine to the warehouse. Several marking systems are available for this purpose. The use of indicator paints, tags or tape attached to each crate is helpful only to the extent that a change in color indicates that the crate has been in a retort and that the steam has been turned on.

It must be understood that these indicators will *not* measure process time or the adequacy of the process. The use of a heat indicator, with the proper recorder charts and production records, provides added assurance that each basket was processed at the correct temperature and time.

(3) A distinctive marker be hung from the retort opening when the retort holds unprocessed cans. It should be placed so that the door or lid cannot be closed before the marker is removed.

(4) A retort not be closed until the operator indicates that he is ready to start the process.

(5) Cans of unknown status with regard to process be punctured and thrown out.

(6) Adequate precautions be taken to clear exhaust boxes and precookers of all cans at the end of each day's operations.

Rapid Handling and Prompt Retorting of Filled Cans

A long holding period between filling and closing or between closing and retorting cans may result in souring, off-flavor, and loss of vacuum. Depending upon the nature of the product, processing should follow within one-half to one hour after closure. If longer times are required to obtain enough cans to fill a retort, processing of partial retort loads should be practiced.

Position of Cans in Retort

Heat penetration in canned foods containing freely flowing liquid is mainly by convection currents. The general trend of these currents is in a vertical direction, consequently in the product being heated they seek channels which permit such motion. Where their progress is impeded or baffled by solid material, the currents flow around the obstruction to the nearest point at which they can pass. For this reason the alignment of certain foods in the can is of the greatest importance as regards heat penetration.

Where the packing or filling of any product in the can results in stratification, the cans should be processed in such position that the plane of stratification is vertical. In the case of asparagus, for example, the spears are generally parallel and tightly packed in the cans in a vertical position, so that the channels containing liquid are parallel to the spears. As a result, the speed of heat penetration is greater when the cans are placed upright in the retort.

Another example is spinach. In No. 10 cans especially, the spinach is placed in more or less horizontal layers. Convection currents, therefore, travel to the center of the cans faster when the cans are processed on their sides rather than in a vertical position.

Products such as peas and cut green beans consist of small solid bodies, fairly uniform in size and evenly distributed throughout a liquid medium; consequently the rate of heat penetration is little influenced by the position of the cans in the retort.

Starting a Process–Venting–Come-up Time

At the time the steam is turned on, all bleeders and all valve-controlled vents should be wide open. All bleeders should be left open during the processing period.

Venting. The valve-controlled vents should be left open for a sufficient time after steam is turned on to ensure that all air is swept out of the retort, so that no "pockets" of air remain among the cans. There is a tendency for steam to by-pass the load of cans and to escape through the vents before all air has been driven from the stacks of cans. An air-steam mixture in the retort will cause underprocessing.

The timing of the process should not begin until the retort has been properly vented and the processing temperature has been reached. When the retort has reached the processing temperature desired, check the temperature indicated on the mercury and recording thermometers. Do not rely on the pressure gauge for an indication of the retort temperature. It is not serious if the chart indicates a temperature slightly lower than the mercury thermometer, but it must never be higher. When the temperature is correct, start timing the process. Use an accurate clock for this purpose, not a wrist watch or the recorder chart.

Come-up Time. There is a minimum limit for the come-up time because of the necessity for removing the air from the retort by venting during this period. When venting is inadequate for rapid removal of the air, a very short come-up time is likely to result in under-processing. A come-up time shorter than the minimum for which the retort has been demonstrated to give satisfactory results should not be used.

With some vacuum-packed products, it is advisable to heat the cans sufficiently to dissipate the internal vacuum before the pressure in the retort is permitted to become greater than two pounds, otherwise the cans may panel or even collapse.

Short High Temperature Processes

For a product having rapid heat penetration, very short processes at comparatively high temperatures are sometimes used. It is especially important that such processes have the most careful control. An error in either time or temperature in a short high temperature process will have a much greater effect upon the total sterilizing value of the process than a like error will have in a longer process at a lower temperature.

Cooling and Storage

The duration of the water-cooling period should be sufficient to bring the average temperature of the contents to 100°F, but water cooling should not be continued to the point where external rusting of the container may occur. In humid locations water cooling to a temperature of 100°F may lead to external rusting. In that case, the cans should be mechanically dried, or water cooling should be carried to approximately 120°F and the cans subsequently air cooled before they are put into storage. When cans whose contents are at temperatures substantially above 100°F are stacked closely together, and especially if they are sealed in fiber cases, they cool so slowly that spoilage by thermophilic bacteria and injury by heat to the quality of the product (stack-burn) may occur.

Air Cooling

If the capacity of the water-cooling equipment is inadequate, or if a shortage of water is experienced, the cans should be stacked so that they will air cool rapidly. Air cooling is sometimes used for products such as hominy in order to effect a proper swelling of the product. It is suggested that the cans be stacked on their sides in single rows, allowing space for air circulation between the rows. The stacks should be arranged paralled to the cross ventilation of the warehouse. Careful attention to the factors affecting air circulation may serve to prevent retarded cooling and to safeguard against spoilage by thermophilic bacteria.

Initial Temperature

The term "initial temperature" as used herein designates the average temperature of the can contents at the time steam is turned on for the process. Just prior to the start of the process, the contents of the container used for checking the initial temperature should be shaken or stirred and the temperature determined. This container should be representative of the coldest cans in the retort load and should have an initial temperature equal to or greater than the initial temperature specified in this section. *The specified initial temperature is to be regarded as a prerequisite minimum of the process suggested.* If a can is closed at a temperature higher than that of the canning room atmosphere and is then held for some time in the room before it is processed, the contents will cool but the temperature at the center of the can may not be appreciably less than the closing temperature. It is for this reason that, from the standpoint of sterilization, the contents of the container should be stirred or shaken and the initial average temperature determined just prior to the start of the process.

"Initial temperature" should not be confused with "closing temperature." Except when vacuum packing or steam flow closure is practiced, the closing temperature is the major factor influencing the final vacuum obtained in the cans and is an important consideration in preventing undue can strain or damage during processing and cooling and in avoiding development of flippers. The closing temperature must be sufficiently high to satisfy these needs.

Acidification

The sterilizing of low-acid products in boiling water is impracticable without controlled acidification procedures.

Unless some acidification procedure is followed, sterilization of certain low-acid foods by heat produces unmerchantable products. Notable examples are Globe artichokes, pimientos, onions, and peppers. A health hazard may be involved in the case of insufficient acidification. Under proper control such products may be acidified to the point where they are no longer low-acid and then be processed in boiling water. However, this procedure should not be followed without consulting a laboratory connected with the canning industry. Experience has shown that careful supervision of all details, particularly the blanch, fill and brine, is essential when acidification is included in the processing procedure.

GAUGE PRESSURES AND PROCESS TEMPERATURES

The following table shows the gauge pressure corresponding to specified process temperatures at various altitudes:

Gauge Pressure Corresponding to Specified Process Temperatures at Various Altitudes

Temp. Deg. F.	Sea Level	Feet above sea level 500	1000	2000	3000	4000	5000	6000	Temp. Deg. C
200	....	....	....	....	....	....	....	....	93.3
205	....	....	....	....	....	....	0.5	0.9	96.1
210	....	....	....	0.4	0.9	1.4	1.8	2.3	98.9
212	0.0	0.2	0.5	1.0	1.5	2.0	2.4	2.9	100.0
215	0.9	1.1	1.4	1.9	2.4	2.9	3.3	3.8	101.7
220	2.5	2.7	3.0	3.4	3.9	4.4	4.9	5.3	104.4
225	4.2	4.5	4.7	5.2	5.7	6.2	6.6	7.1	107.2
230	6.1	6.3	6.6	7.1	7.6	8.0	8.5	9.0	110.0
235	8.1	8.3	8.6	9.1	9.6	10.0	10.5	11.0	112.8
240	10.3	10.5	10.8	11.3	11.7	12.2	12.7	13.1	115.6
242	11.2	11.4	11.7	12.2	12.7	13.1	13.6	14.1	116.7
245	12.6	12.9	13.1	13.6	14.1	14.6	15.0	15.5	118.3
248	14.1	14.3	14.6	15.1	15.6	16.0	16.5	17.0	120.0
250	15.1	15.4	15.6	16.1	16.6	17.1	17.5	18.0	121.1
252	16.2	16.4	16.7	17.2	17.7	18.1	18.6	19.1	122.2
255	17.8	18.1	18.3	18.8	19.3	19.8	20.2	20.7	123.9
260	20.7	21.0	21.2	21.7	22.2	22.7	23.1	23.6	126.7

Precautions for Handling Filled Cans

The installation of many of the newer labor saving devices for handling filled cans has introduced certain hazards which, if not minimized, may result in some spoilage with the best possible double-seam construction. Before the cans are thoroughly cooled, the seams are slightly expanded and the compound lining is somewhat soft or plastic. In addition to the usual attention to good seam construction, precautions must be taken in handling the cans before they are thoroughly cooled to prevent even small dents on, or near, the double-seams. This involves elimination of fast runways with sharp turns and abrupt stops for handling filled cans both before and after processing. Care should also be taken to avoid conditions which would strain the seams during the processing or cooling; e.g., excessive holding time of unprocessed cans, inadequate exhausting or too rapid release of pressure during cooling. In cooling under pressure, particular attention must be paid to the magnitude of the pressure and the length of time it is maintained since the greater the differential pressure between the inside and the outside of the can, the greater the tendency toward forcing minute quantities of the cooling water into the can during this critical period. Bacterial content water should be kept as low as possible since the spoilage hazard is reduced in proportion to the number of microorganisms present.

CAN DIMENSIONS

The can sizes are given in the nomenclature usually employed in the industry, which avoids the confusion incident to conflicting local names of cans.

In this system the cans are identified by a statement of their dimensions (over-all diameter and over-all height). Each dimension is expressed as a number of three digits. The left-hand digit gives the number of whole inches, while the two right-hand digits give the additional fraction of the dimension expressed as sixteenths of an inch.

The first number given in the size of each can is the diameter, and the second number is the height. For example, a No. 303 can, designated as 303 x 406, is 3 3/16 inches in diameter and 4 6/16 inches high, that is, within manufacturing tolerances.

The dimensions are "over-all," the diameter being measured to the outside of the double seam, and the length including the entire seam at each end of the can.

COOLING CANS UNDER PRESSURE IN RETORTS

The following procedure for cooling cans under pressure is taken from the Bulletin "Retort Installation, Equipment and Operating Procedures" issued by Continental Can Company, Metal Division, Research and Development Department.

Pressure Cooling Hook-Up

Manually operated pressure cooling installations are comparatively simple and are shown in illustrations (Fig. 2 and 3) suitable for both vertical and horizontal retorts. There are two procedures for pressure cooling, one using steam and the other air, to maintain a desired pressure in the retort during cooling and thereby prevent buckling.

Pressure Cooling Under Air Pressure

The use of air for this imposed pressure is preferable over steam due to the noncondensable properties of air. This makes the operation considerably more fool-proof as it eliminates the possibility of accidentally condensing the steam in the retort, thus producing a partial vacuum and increasing the buckling hazard. A pressure control system is essential to insure moderate accuracy in maintaining the desired air pressure inside the retort. A pressure reducing valve serves as an inexpensive controller. One such valve placed in a header supplying a bank of retorts is sufficient for all the retorts in that bank. Air lines to each retort should be 3/4 inch to 1 inch size with the headers sized in accordance with the number of retorts which might be pressure cooled simultaneously.

The following formulae and the tables are designed to aid in the calculation of the amount of air required for pressure cooling, receiver or supply tank size, and compressor size required. It is suggested that all calculations be based on the volume of an empty retort in order to insure an ample air supply when only a partial load has been processed. Calculations should be made on a single retort and if cooling should start simultaneously on more than one, the requirements would be governed accordingly.

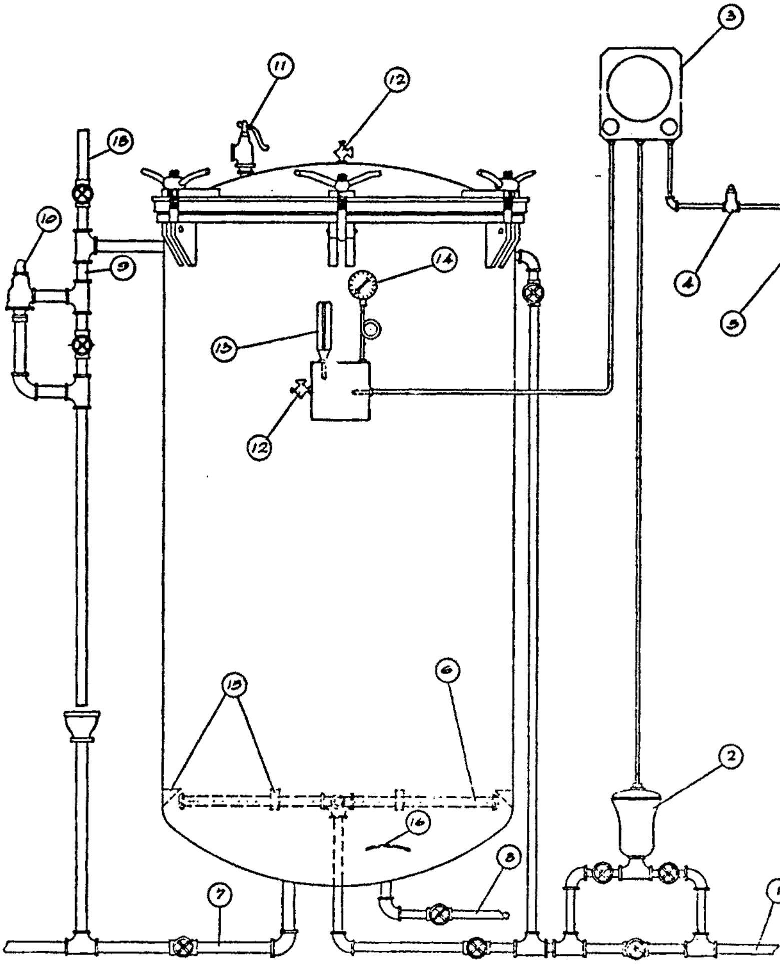


FIGURE 2

PRESSURE COOLING UNDER STEAM PRESSURE

① STEAM ② REGULATING VALVE ③ CONTROLLER ④ REDUCING VALVE, AIR ⑤ AIR FILTER ⑥ STEAM DISTRIBUTOR ⑦ DRAIN ⑧ WATER ⑨ OVERFLOW ⑩ PRESSURE RELIEF VALVE ⑪ POP SAFETY VALVE ⑫ BLEEDERS ⑬ INDICATING THERMOMETER ⑭ PRESSURE GAUGE ⑮ BASKET SUPPORTS ⑯ WATER INLET BAFFLE ⑰ AIR FOR CONTROLLER ⑱ VENT ⊕ MANUAL VALVES.

(Courtesy Continental Can Co.)

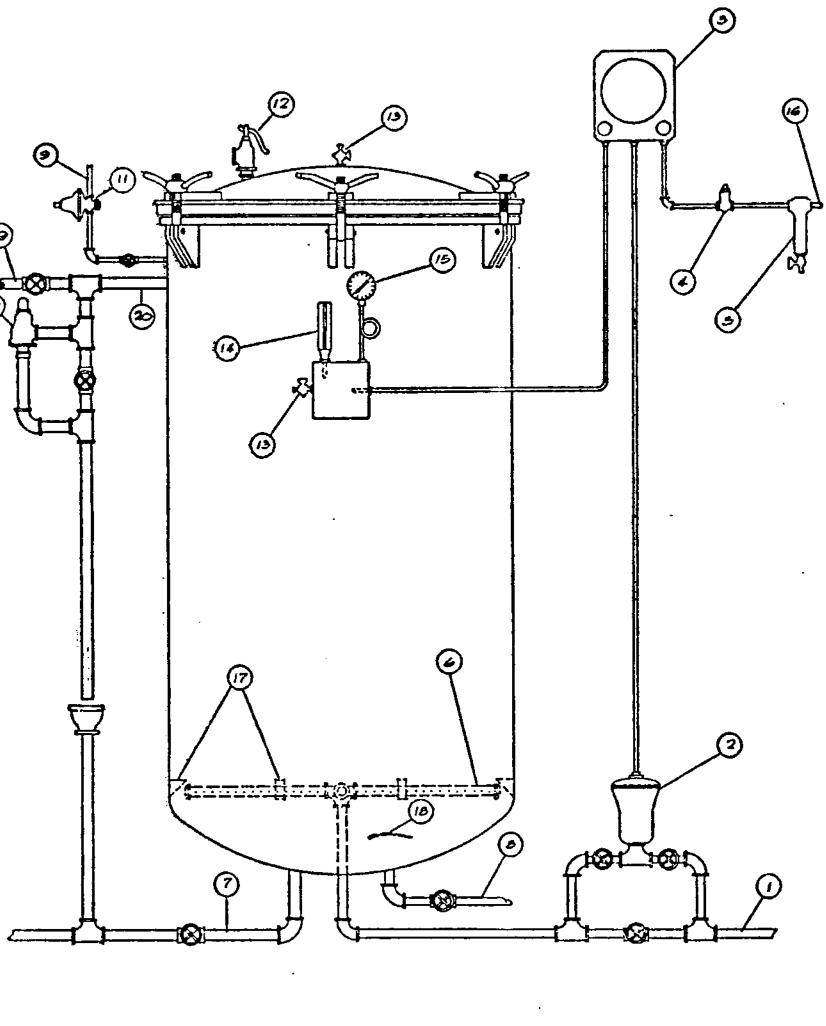


FIGURE 3

PRESSURE COOLING UNDER AIR PRESSURE

(1) STEAM (2) REGULATING VALVE (3) CONTROLLER (4) REDUCING VALVE, AIR (5) AIR FILTER (6) STEAM DISTRIBUTOR (7) DRAIN (8) WATER (9) AIR (10) PRESSURE RELIEF VALVE (11) REDUCING VALVE OR CONTROLLER (12) SAFETY POP VALVE (13) BLEEDERS (14) INDICATING THERMOMETER (15) PRESSURE GAUGE (16) AIR FOR CONTROLLER (17) BASKET SUPPORTS (18) WATER INLET BAFFLE (19) VENT (20) OVERFLOW ⊕ MANUAL VALVES.

(Courtesy Continental Can Co.)

FREE AIR (ATMOSPHERIC PRESSURE) REQUIRED PER RETORT

V_1 =Volume of retort in cubic feet.

P_1 =Atmospheric pressure, 14.7 p.s.i.

V_2 =Volume of free air to obtain Pressure P_2 in retort.

P_2 =Pressure of cooling (absolute of 14.7 + gauge reading)

$V_2 = V_1 \times P_2 \div P_1$

Receiver Capacity–Receiver Capacity per Retort = $V_2 \div$ free air available per cubic foot of receiver capacity.

Compressor Capacity–Compressor Capacity (cubic feet free air per minute) = V_2 time in minutes between consecutive cooling operations.

Examples: (Retort size)–42 inch x 72 inch.

Cooling pressure (gauge)–10 p.s.i.

Time between consecutive cooling operations–5 minutes.

Receiver pressure (gauge)–100p.s.i.

To determine the volume of free air necessary to obtain a gauge pressure of 10 p.s.i. in the retort, solve for V_2 in the equation $V_2 = V_1 \times P_2 \div P_1$ as follows:

V_2 =58 (From Table 2) x 24.7÷14.7=97.5 cu. ft. per retort.

The receiver or supply tank capacity necessary for one retort would then be 97.5 ÷6.10 (From Table 1) or 16 cu. ft.

The compressor capacity in cubic feet of free air per minute would be a minimum of 97.5÷5 (minutes between consecutive cooling operations) or 19.5 cu. ft. per minute.

Cubic Feet of Free Air (14.7 p.s.i.) Available per Cubic Foot of Receiver Capacity

Cooling Pressure (Gauge)	Receiver Pressure – P.S.I.									
	60	70	80	90	100	110	120	130	140	150
10 p.s.i.	3.40	4.10	4.75	5.45	6.10	6.80	7.50	8.20	8.85	9.55
12.5 p.s.i.	3.20	3.90	4.60	5.30	5.95	6.65	7.30	8.00	8.70	9.35
15 p.s.i.	3.05	3.75	4.40	5.10	5.80	6.45	7.15	7.85	8.50	9.20
18 p.s.i.	2.85	3.55	4.20	4.90	5.55	6.25	6.95	7.65	8.30	9.00
21 p.s.i.	2.65	3.35	4.00	4.70	5.35	6.05	6.75	7.45	8.10	8.80

Retort Volumes – Some Common Sizes

Vertical – 42 inch x 72 inch-58 cu. ft.
Vertical – 42 inch x 84 inch-67.5 cu. ft.
Vertical – 42 inch x 96 inch-77.2 cu. ft.
Vertical – 42 inch x 108 inch-87.0 cu. ft.
Horizontal – 42 inch diameter – 9.65 cu. ft. per foot of length
Horizontal – 54 inch diameter – 15.9 cu. ft. per foot of length
Horizontal – 60 inch diameter – 19.7 cu. ft. per foot of length

Minimum Requirements for 3- and 4-Crate Vertical Retorts

Steam Pressure	90 p.s.i.
Steam Inlet	1 inch
Steam Regulating Valve	Consult Manufacturer
Steam Spreader	1 inch
Steam Spreader–Hole Size	3/16 to 1/4 inch
Steam Spreader–Number of Holes	47 to 62 (3/16 inch)
Vent Line	1-1/4 inch
Vent Valve	1-1/4 inch–Gate
Bleeders	1/8 or 1/4 inch petcocks
Overflow	1-1/4 (Gate valve)
Drain	Not Critical–1-1/2-2 inch (Gate valve)
Safety Valve	Meet A.S.M.E. or local codes
Water Pressure	40 p.s.i.
Water Inlet	1 inch
Air for Control Instruments	20 p.s.i., 1/4 inch tube or 1/8 inch pipe
Air for Pressure Cooling	3/4 inch, 40 p.s.i.
Pressure Relief Valve	1-1/4 inch (adjustable)
Temperature Control Instrument	Control to ± 1°F.

Minimum Requirements for Horizontal Retorts

	TO 8 FT.	8-15 FT.	OVER 15 FT.
Steam Pressure	90 p.s.i.	100 p.s.i.	125 p.s.i.
Steam Inlet	1-in.	1-1/4-in.	2-in.
Steam Regulating Valve		Consult Manufacturer	
Steam Spreader	1-in.	1-1/4-in.	2-in.
Steam Spreader–Hole Size	3/16-in.	3/16-in.	3/16-in.
Steam Spreader–Number of Holes	47-62 (3/16-in.)	81-108 (3/16-in.)	183-244 (3/16-in.)
Vent Line	1-1/4-in.	1-1/2-in.	2-1/2-in.
Vent Valve	1-1/4-in., Gate	1-1/2-in., Gate	2-1/2-in., Gate
Bleeders		1/8 or 1/4-in. Petcocks	
Overflow	1-1/4-in. (Gate valve)	1-1/2-in. (Gate valve)	2-1/2-in. (Gate valve)
Drain–Not Critical	1-1/4-in. (Gate valve)	1-1/2-in. (Gate valve)	2-1/2-in. (Gate valve)
Water Pressure	40 p.s.i.	50 p.s.i.	60 p.s.i.
Water Inlet	1-in.	1-1/4-in.	2-in.
Air for Control Instruments		20 p.s.i. 1/4 inch Tube or 1/8 inch Pipe	
Air for Pressure Cooling	1-in., 40 p.s.i.	1-1/4-in., 50 p.s.i.	2-in., 60 p.s.i.
Pressure Relief Valve	1-1/4-in.	1-1/2-in.	2-1/2-in.
Safety Valve		Meet A.S.M.E. or local codes	
Temperature Control Instrument		Control to ± 1°F.	

Venting Schedule for 3- and 4-Crate Vertical Retorts

Steam Inlet	Vent	Time, minutes: Without Divider Plates	Time, minutes: With Divider Plates	Temperature, °F.: Without Divider Plates	Temperature, °F.: With Divider Plates
1 inch	1¼ inch	4	6	220	225
1¼ "	1½ "	3	5	220	225
1½ "	2 "	3	5	220	225
2 "	2½ "	2	4	225	230

Number of Cans Per Retort, Vertical Retorts — Cans Stacked on End

Can Size	Approximate No. Cans per Retort 3-Crate	Approximate No. Cans per Retort 4-Crate
211x109	6250	8330
200	4310	5750
212	3360	4480
300	2880	3840
400–414	1920	2560
600	1440	1920
300x108	4470	5970
206	2720	3630
308	1710	2280
400–414	1370	1820
509	1030	1370
303x406	1200	1600
509	910	1210
307x203	2590	3450
306	1440	1920
400–409	1150	1330
510	860	1150
401x411	730	970
404x307	820	1100
414	660	880
700	330	400
603x700 (Standard Crate)	190 (Top Crate 3 layers) 160 (Cans on side)	240 (Top Crate 3 layers) 160 (Cans on side)
603x700 (No. 10 Crate)	240 160 (Cans on side	320 160 (Cans on side)

Venting Schedule for Horizontal Retorts

Steam Inlet	Vent	TO 8 FT.				8-15 FT.			
		Time, Min.		Temp., °F.		Time, Min.		Temp., °F.	
		W/O D.P.	With D.P.	W/O D.P.	With D.P.	W/O D.P.	With D.P.	W/O D.P.	With D.P.
1 inch	1¼ inch	4	6	220	225	—	—	—	—
1¼ "	1½ "	4	6	220	225	6	8	220	225
1½ "	2 "	4	6	220	225	6	8	220	225
2 "	2½ "	3	5	225	230	5	7	225	230

D.P. = Divider Plates

Number of Cans Per Retort Vertical Retorts—Cans Scrambled

Can Size	Approximate No. Cans per Retort 3-Crate	Approximate No. Cans per Retort 4-Crate
12 oz. oblong	1120	1500
202x214	3000	4000
211x109	4700	6200
200	3200	4300
212	2500	3300
300	2150	2900
400	1500	1950
414	1450	1900
600	1080	1400
300x108	3300	4500
206	2000	2700
400—411	1050	1400
509	760	1000
303x406	975	1300
509	680	900
307x203	1980	2590
306	1080	1440
400	900	1200
409	850	1140
510	650	850

Pressure Cooling Under Steam Pressure

Pressure cooling with steam, of course, does not require a compressor system and air lines. However, such an operation requires careful and trained operators since mishandling a few retort charges could easily incur losses sufficient to purchase and install an air system. If steam is used, one should remember that a baffle plate should be placed over the water inlet to prevent splashing which might cause condensation of the steam in the retort.

Water Process With Superimposed Air Pressure

It is usually desirable and oftentimes necessary to process cans having large areas of flat surface in superheated water and with superimposed air pressure. Retort hook-up for this procedure is practically the same as for pressure cooling with air. The water temperauture is controlled by a temperature controller to admit steam for heating and a separate control system is used for controlling the superimposed air pressure. A source of hot water for filling the retort is advisable in order to reduce come-up time. Insulated storage tanks for hot water are often used, with pumps for transferring water to and from the retorts. A supply of compressed air capable of maintaining pressures up to 30 p.s.i. in the retort is required.

Automatic Operation

Hook-ups for automatic operation vary considerably depending upon the extent of automatic operation desired and the requirements determined by the type of the particular supplier's system selected. Such systems may vary from a simple timed process cycle through very complex systems which carry out all steps through the venting, processing, and pressure cooling cycles. All such installations must be consistent with all of the fundamental requirements for efficient retort operation. The manufacturer of the automatic system selected should be consulted regarding proper installation of the control and operating equipment, and the final hook-up should be checked by someone experienced in retort hook-ups and operation.

RETORT MAINTENANCE AND TESTING

Retorts like all pressure vessels are subject to failure if subjected to excessive pressures. A periodic hydrostatic test of all retorts should be made to minimize the possibility of such failures and for the protection of the operators and other adjacent personnel. Such tests show up defects due to rusting and wear and these faults may then be corrected. The hydrostatic test is simple and can easily be made either by maintenance personnel or under the supervision of insurance inspection. In some states such tests are mandatory, and are made by state or local government agencies. In making such a test, all safety valves, pressure release systems, etc. are removed and the openings thus made plugged or capped. A test gauge is installed, replacing the regular retort gauge. The retort is then competely filled with water, all over-flows, etc., closed and further water pressure is imposed on the entire system to the required testing pressure. This pressure is maintained for a time sufficient to allow for a visual inspection for any leaks. Standard retorts are constructed for a maximum operating pressure of 15 p.s.i. and should be tested to 30 p.s.i.; ASME units constructed for working pressures of 16 to 40 p.s.i. tested to 80 p.s.i. and ASME units for 41 to 60 p.s.i. should be tested at 120 p.s.i. It is suggested that the complete retort system be so checked once each year.

All manually operated valves should be carefully checked and repaired or replaced when found to be faulty. The valves which do not close properly or tend to stick in any position may be the cause of improper functioning of any of the retorting cycles. Improperly packed valve stems are very annoying and dangerous to the operator and any leaking packing glands should be repaired immediately.

The efficiency of retort performance will deteriorate if retorts are not adequately maintained at regular intervals. In addition to the standarization of thermometers and pressure gauges, the gaskets, closure system, valves, steam traps, air supply system bleeders, steam spreaders, and water spreaders must be examined to make sure that each piece of equipment is in good operating condition.

The following defects have been discovered in poorly maintained reorts:

1. Broken steam spreader pipes.

2. Corrosion of holes in the steam spreader to the degree that the openings are larger than specified.

3. Inoperative steam traps which allow water to accumulate in the bottom of the retort. This situation is especially serious in retorts with top steam entry.

4. Bottom bleeders filled with scale resulting in a condensate volume which exceeds the capacity of the bleeder.

5. Inadequate air flow in retorts used for glass containers causing poor circulation of water and poor distribution of heat.

6. Retort closure failures which cause plant damage and endanger the lives of plant personnel.

7. Faulty manually-operated water and air valves have caused questioning of the adequacy of processes for low acid food.

TESTING AND ADJUSTING MERCURY THERMOMETERS

Because of the importance of thermometers in conjunction with retort operation, advice given by National Canners Association is reproduced here in detail.

Thermometers are the basic reference for the correct processing temperature. It is imperative that they be accurate, dependable, and easily seen by the operator. They should be checked for accuracy at least once a year against a standard instrument. The range should be 170° to 270°., with scale divisions not greater than 2°F. Up to now, only mercury-in-glass thermometers have met all requirements for accuracy and dependability. The following testing and adjusting procedure is suggested:

Equipment Needed

1. *Standard thermometer.* The standard thermometer should be purchased to meet the following specifications:
   a. Scale - at least 7 inches.
   b. Range - 170°- 270°F.
   c. Not less than 2 divisions - preferably 1.
   d. Threaded to fit ¾-inch pipe fittings.
   e. Factory standardized at 212°, 230°, 240°, 250°, and 260°F.
   f. Must be furnished certificate of standardization indicating corrections and case temperature at which thermometer was standardized (140°F case temperature preferred.)

2. Cross made of ¾-inch pipe fittings for holding 3 thermometers. *(see illustration)* The couplings which hold the thermometers should have 1/16-inch drilled holes as bleeders.
3. A supply of ¼-inch pipe fittings, plugs, and reducers, so that the equipment can be installed on any type of retort.
4. Two couplings for angel thermometer.
5. One 15-inch crescent and two 15-inch Stillson srenches.
6. Ink or paint and pen for identifying thermometers.
7. Warding file to file scale plate slots.
8. Tin snips to cut scale plates when too long.
9. Small screw driver with clip for holding screws - to be used on screws in thermometer scales.
10. Rags and steel wool for cleaning thermometer glass and scales.
11. Hand drill.
12. A No. 47 drill for drilling out holes when screws break off.
13. Tap and holder - 4/40 for tapping holes after drilling
14. Extra screws ¼-inch, 4/40 brass R.H. for scale plates.
15. Extra screws for cases.
16. Flashlight.
17. Pliers.
18. Gloves.

Procedure for Testing

1. Remove a retort thermometer and install the testing equipment in its place.

2. Remove the thermometers to be tested. Use the crescent wrench for removing thermometers because it is less likely to slip, and there is less danger of damaging the surfaces or breaking the stems.

3. Remove the faces from the thermometers and place two of them in the test equipment. The standard thermometer should be in the middle. Check for loose stems by attempting to move them up and down. (If loose, destroy or send back to manufacturer for repair or replacement.)

4. Bring the retort to the required temperature, making certain to vent sufficiently long to eliminate all air.

5. Open the valve on the test equipment and allow the thermometers to come to equilibrium, which will require at least 15 minutes. If the temperature fluctuates it may be steadied by throttling the control valve. Examine mercury column carefully to detect any separation. (Separated mercury columns may sometimes be remedied by cooling the bulb overnight with dry ice.)

6. Take at least 4 temperature readings over a period of several minutes to make certain the thermometers are at equilibrium.

7. Loosen the screws on the temperature scale of the thermometers being tested and bring into agreement with the standard thermometer by moving it

up or down. If it cannot be moved enough to make the adjustment, remove the scale from the thermometer and file screw slots longer, or cut off the end of the scale, whichever may be necessary.

8. Tighten the scale adjustment screws and take another reading to make certain the thermometers are properly standardized.

9. Close the valve, remove the plant thermometers, and replace them with two more. Open the valve and proceed as above.

10. Number each thermometer for further identification. Mark broken thermometers in such a way that they will not be used before repair or replacement.

11. Clean the case glasses and replace the thermometer faces.

Maintenance of Other Retort Equipment

Retort controllers should be checked for accuracy by the manufacturer of the specific controller. This service is usually rendered by the manufacturer through a contract at a fixed price calling for two to three visits a year. In the event of an emergency on the part of the canner, he may contact the manufacturer who will make a special service call at a pre-established price. The controllers are usually checked by means of a standardized thermometer or hot water bath of known temperature.

Safety valves should be tested frequently. Pressure gauges should be checked for accuracy at least once a year. Water valves and compressed air valves, especially the latter, should be checked frequently for leaks.

Before each operating season and after any considerable idle period, the entire retort hook-up should be examined carefully, and each retort should be brought to processing temperature, without a load, to test the steam line for leaks, to check the vents, and to test the instruments and control equipment for proper operation and accurate recording. *Never introduce water into an empty retort after testing until the pressure has been released.*

POST PROCESSING CAN HANDLING

Food preservation by heat processing in cans depends upon the fulfillment of two conditions: 1) the destruction by heat of bacteria capable of spoiling the food product, and 2) the prevention of bacterial recontamination of the product by means of the sealed container. Although heat processes have been developed that will insure the destruction of spoilage organisms normally present in the canned product, there remains the hazard of re-entry of spoilage bacteria during post processing can handling operations.

The advent of double reduced tinplate and aluminum cans calls for a fresh approach to can handling methods. Also the trend in modern canning practice has been toward higher final vacuums in canned foods. Subsequent to the heat processing operations, the canned product is usually cooled by water. During the cooling operations, the filled cans go from pressure to vacuum and, in most instances, enter automatic or semi-automatic can handling lines. When filled cans are handled in automatic equipment at high speeds, small deformations of the seams may be more significant as spoilage factors than they are under slow speed, low impact conditions.

Spoilage Factors

1. The quality of the can double seams.

2. The presence of bacterial contamination in cooling waters or on wet runways.

3. Excessive abuse due to poor operation or adjustment of the filled can handling equipment.

Operating Precautions

1. Inspect can seams frequently to insure that they are properly formed and that seamer adjustments have not exceeded tolerances.

2. Periodically inspect the can handling system from the closing machine to the caser. Where rough handling of the cans is apparent, smooth out the operation to minimize can seam and body damage. Roll in casers must be adjusted carefully to prevent violent can to can contact or can seam to can body contact.

3. Do not allow cans to drop freely into crates from closing machine discharge tables.

4. Do not overfill the retort crates. This will eliminate protruding cans which could be crushed by the crate bales or by crates placed on top of them in the retort.

5. Prevent sharp impacts between filled crates or against protruding points.

6. Operate crate dumps smoothly to prevent impact denting.

7. Chlorinate all cooling waters to a point where there is at least one part per million chlorine residual at the discharge end of the can cooler. If chlorination renders the water corrosive, use a suitable corrosion inhibitor.

8. Thoroughly scrub and sanitize all tracks and belts which come into contact with the can seams at intervals frequent enough to prevent bacterial build-up.

9. Replace all worn and frayed belting, can retarders, cushions, etc., with new non-porous material.

10. Run cans through a can dryer immediately on leaving the cooling system or tip the full retort baskets to drain water trapped on can ends and allow the cans to dry in the retort crates before discharging into the can handling unit to lessen the recontamination hazard.

High velocity air blasts over the body and ends of cans removes excess water and maintains dry can tracks. Dry conditions do not encourage the development of bacterial contamination.

Bacteria may develop on can handling equipment in a film of water, lubricants or other material. Bacterial contamination of the contact point of the can body and double seam can be significant and drying methods that permit contamination and then remove visible water but leave contaminated water at this point, may not be sufficient.

Chlorinated cooling water (Item 7) will tend to depress bacterial numbers on wet can runways after cooling, but the effect rapidly dissipates in relation to the distance of travel from the cooler.

11. Deliberate wet conditions can be tolerated by continuously running or spraying a sanitizing solution of water containing 3 to 5 ppm of free residual chlorine on the can tracks. Adequate control of continuous drippage must be provided and the cans must be dried before entering the labeler.

12. Can transporting belts and elevators, unless completely dry, should be continuously sprayed at the beginning of the return with water containing 3 to 5 ppm of free residual chlorine.

Sanitary Design

Under present day production pressures, filled and sealed can handling equipment must be designed to minimize pick-up of bacterial contamination around the double seams. The design must also prevent shock, strain, or even small denting of the cans, particularly on or near the seams. This may cause aspiration of minute amounts of moisture even through well made seams. Spoilage may result if the moisture contains bacteria. The engineering and design objectives of post processing can lines should include the above considerations: 1) minimize contamination, and 2) prevent shock, strain and denting (rough handling). The following are recommendations to help accomplish these objectives:

1. Keep handling to a minimum. All switchbacks, quarter turns, loweraters and other changes of can direction or orientation should be engineered according to can speed, size and weight to minimize strain. In general, sharp reversals of direction should be avoided. Quarter turns should have a long radius to handle the cans gently.

2. The need of "bumpers" should be avoided, but where necessary they should be of non-absorbent, easily cleaned material. Fabrics, wood or absorbent core belting are not satisfactory as they will support high bacterial populations that cannot be eliminated. This source of contamination is at the point where shock and seam strain occurs, and the harder the bump the greater the hazard. Such bumping also increases the hazard from contamination picked up from subsequent equipment.

3. If possible, eliminate all rolling cans where can to can contact may occur. Each can should be positively controlled as far as practical, such as by flat belts or cables, and the drive mechanism automatically controlled so cans cannot slam into each other or have seams strained or damaged by belts and cables continuing to run under jammed (stopped) cans. Plastic covered cables are sanitary and considerably reduce friction and abrasion between cable and cans. Line flow controls, if properly installed in right locations, will permit an even flow of cans without jamming and will shut off power-driven belts or cables when conveyors are full.

4. When cans are rolled, the slopes, can spacing and can speeds should be engineered to prevent cans bumping each other. This is a common cause of seam strain and damage. Can track adjustments and can and guide clearance tolerances

should be such as to assure that any unavoidable can to can contact will be seam to seam contact and not seam to body contact.

5. When cans are rolled the double seams should not contact the runway surface except in coolers. In angle iron runways installation of metal half-rounds is one possibility to keep the can double seams from contacting wet or damp angle iron guides.

6. Drill weep holes to prevent water accumulating in the tracks behind the half rounds. In all cases install properly, or use drip pans, to prevent water from one can track dripping onto another track or cans below. Also consider safety, housekeeping, appearance and comfort hezards caused by dripping water.

7. Where cans pass between belts or other retarders, and on some elevators, cut away the contacting material so that the can double seams ride free of contact. Also do not slow the can to the extent the following cans will bump into it.

8. At palletizers and other take-off and transfer points, provide for a continuous and gentle deceleration of the cans. Usually this requires a take-off belt so the cans are moved out of the way of the following can so violent impact cannot occur. Do not run cans at high speed into a dead end where they are stopped suddenly by bumping into the can ahead.

9. Dirt and organic debris, as well as bacterial contamination will accumulate on can handling equipment. The equipment must be designed and installed so it can be cleaned. This means it must be accessible for cleaning and as water, detergents and sanitizers will be used, in a location that provides drainage. In some installations drip pans or other shields will be necessary.

STERILIZATION IN STILL RETORTS–GLASS CONTAINERS.

Foods packed in glass containers are increasing in volume and variety. Because of the importance of proper processing and the special precautions which must be taken, the National Canners Association Bulletin 30-L "Processes for low-acid canned foods in glass containers" is quoted in part in this and the following page.

Importance of Proper Equipment and Procedure

Foods in glass containers are processed under water with superimposed air pressure. In order to be certain that all jars are commercially sterilized, careful control and recording of temperatures and pressures; and adequate circulation of water to ensure uniform temperatures are essential. This is true because processes for canned foods are determined by tests made with the jars at a definitely controlled and specified temperature and pressure, and when these processes are applied in commerical practice equivalent conditions must be met. The suggestions under "Equipment" and "Procedure" are based on the results of careful studies to determine what types of equipment and procedure may be relied upon to give the required heat treatment under commercial conditions. Close supervision of the cook room and careful attention to details are essential to ensure successful processing.

Equipment

Retort–The processes contained in this section are for discontinuous, non-agitating (still) retorts. For other types of sterilization systems, processes should be obtained from a laboratory connected with the canning industry.

The retort must have strength sufficient for processing glass containers under water with superimposed air pressure. Construction and testing should be done in compliance with government and insurance regulations.

Since either vertical or horizontal retorts may be used, the general details of these two types will be considered collectively and the specific details outlined separately.

Retort Installation–For proper operation each retort should have the following items of equipment:

(1) *Door or Lid-Securing Devices and Gaskets.* Before subjecting the retort to pressure, the door or lid-securing devices should be examined carefully and worn parts replaced. The gasket should be checked to make sure it is tight and in good condition.

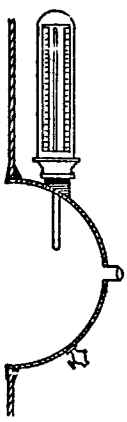
(2) *Safety Valve.* A safety blow-off valve, of at least 2 inch size, should be provided, separate from the overflow and located above the water level. On vertical retorts this should be a side connection with piped outlet. A cross bar should be installed in the safety valve opening to prevent clogging by caps or large pieces of glass. The safety valves should comply in capacity with local safety codes or the A.S.M.E. Code for unfired pressure vessels. The safety valve should be set at least 3 psi. above the maximum operating pressure.

(3) *By-Pass Valves.* All automatic control valves should have manually operated by-pass valves.

(4) *Steam, Air, and Overflow Valves.* To facilitate maintenance there should be a manually operated valve before and after the steam, air control, and overflow valves.

(5) *Drain Valve.* Because of the importance of maintaining the water level and preventing leakage, a 125 psi., non-clogging, water-tight valve is required.

(6) *Crate Supports.* Lugs, tracks, or a saddle type support should be used. A ring is also satisfactory for vertical retorts. In no case should baffle plates be used.



(7) *Thermometer Pocket.* Vertical Retorts. The thermometer pocket or well should:

(a) Preferably be of the hemisphere type having a minimum diameter opening into the retort wall of 9 inches (see sketch.)
(b) If of the rectangular type, have a minimum opening into the retort wall of 8 inches by 8 inches.
(c) Be designed with a depth of 4 inches or more.
(d) Have a provision for the pressure gauge in the same pocket as the thermometer (see diagram, page 216).

(8) *Temperature Control and Indicating Equipment.* Adequate automatic controls are essential. Manual control of temperature is not recommended because the possibility of error is too great.

Control and indicating equipment, such as thermometers and pressure gauges, should be so placed with respect to light and position that they are easily readable.

a. *Indicating mercury-in-glass thermometer.* The thermometer should have a temperature range of not more than 100° F, for example, 170° F to 270° F, and the scale division should be of either one degree or two degrees each—never greater than two degrees. The temperature scale of the indicating thermometer should be at least 7 inches in length.

Thermometers should be installed where they can be easily read and the glass kept clean. A metal guard may be installed if necessary to protect them from damage. A thermometer with a divided mercury column should be replaced. Thermometers should be tested for accuracy against a known accurate standard thermometer upon installation and at least once a year thereafter or anytime their accuracy is questioned.

The thermometer bulbs should be located in such a position that they are beneath the surface of the water throughout the process. On horizontal retorts, it is desirable that this entry be made in the side at the center. The thermometer bulbs should be inserted directly into the shell. In both vertical and horizontal retorts, the thermometer bulb should extend directly into the shell. In both vertical and horizontal retorts, the thermometer bulb should extend directly into the water a minimum of at least two inches without a separable well or sleeve.

b. *Recording temperature indicator.* The chart should be easily readable to 1° F and should be graduated in not to exceed 2° F divisions within the range of plus and minus 10° F of the process holding temperature used. All charts should have a working scale of not less than 3 inches. The bulbs for these indicators should be located adjacent to the bulb of the mercury thermometer, except in the case of a vertical retort equipped with a combination controller-recorder. The recording thermometer should be adjusted to agree with an accurate mercury-in-glass thermometer.

(9) *Location of Temperature Control Bulb.* In vertical retorts the temperature control bulb should be located at the bottom of the retort, below the lowest crate rest, in such a position that the steam does not strike it directly; such as in a "dead" quadrant described under (11) on page 211. In horizontal retorts, the temperature control bulb should be located between the water surface and the horizontal plane passing through the center of the retort, so that there is no opportunity for direct steam impingement upon the control bulb.

(10) *Pressure Control and Indicating Equipment.* Adequate automatic controls are essential. Manual control of pressure is not recommended because the possibility of error is too great.

a. *Water level and pressure controller.* The top layer of jars should be covered with about 6 inches of water, and the overflow located accordingly. The opening of the overflow should be larger than the water supply line. An adjustable pressure relief, or control, valve should be installed in the overflow line of a capacity sufficient to prevent increase in retort pressure when the water valve is wide open.

b. *Indicating pressure gauge.* The pressure gauge should be graduated in 1 or 2 psi. divisions and have a range of 0 to 45, or 0 to 60 psi. The minimum diameter of the dial should be 4½ inches and the gauge should preferably be of a type in which the operating mechanism is independent of the case. The gauge should be connected to the retort by means of a gauge siphon or gooseneck. In a vertical retort the gauge should be located at the the thermometer pocket. In the horizontal retort the gauge may be either in this position or at the top of the retort.

c. *Recording pressure indicator or controller.* The chart should be easily readable and should cover the normal operating range.

(11) *Steam Supply and Introduction.* For reasonable coming-up-times, the steam pressure in the main line to the cook room should be not less than 90 psi. at all times during operation.

The general requirement is for a good steam distributor in the bottom of the retort, providing uniform heat distribution throughout the retort and quick come-up time.

For vertical retorts these results can be achieved by any one of several methods. One means is an assembly of six pipes radiating from a center coupling with fish-tail nozzles at the end of each pipe and directing the steam up the walls of the retort outside the crates. Another means is a four-legged cross in which each pipe leg is perforated with holes directed 15° F below horizontal, along one side only. The legs are arranged in opposing pairs to give alternate live and dead quadrants.

In horizontal retorts, the steam distributor should run the full length of the bottom of the retort with perforations distributed uniformly along the upper part of the pipe.

For details of installation of a steam distribution system, consult a laboratory connected with the canning industry. Details on the mode of operation where the retorts for processing glass are also to be used for steam processing of metal containers may be obtained from a laboratory connected with the canning industry.

(12) *Temperature Controls.* The steam valve arrangement should consist of an automatic, air pressure-to-open, valve or valves.

(13) *Water Level Indicator.* A means of determining the water level in the retort should be provided. This can be accomplished by using a gauge water glass or series of pet-cocks at different levels on the retort, but should be supplemented with an automatic warning device such as that described below. Where the gauge water glass is used, attention should be given to proper safety factors.

Drain valves sometimes leak during a process because of the presence of a piece of glass in the valve, or for some other reason, and this may result in some of the upper layers of jars being above the water line during the process. Jars exposed in this manner would be underprocessed because of the lower temperature of the steam-air mixture. In view of this it is strongly advised that screens be used over drain openings and an automatic warning device, preferably actuating a horn, be installed in each retort to indicate to the operator that the water has fallen below a safe level (See Water Level, page 220).

(14) *Air Supply and Controls.* A reliable supply of compressed air at the proper pressure and a means of introducing it into the retort at an adequate rate are required. The air is required both to maintain water circulation and to maintain the necessary pressure (See page 220). An automatic pressure control unit is recommended for both vertical and horizontal retorts. In both, the air should be introduced with steam at the bottom and in close proximity to the retort to control chatter."

The amount of air pressure required will depend upon the steam pressure in the lines to the retort, and upon the location of the point at which the air is introduced into the steam line. It should be in the range of 50 to 70 psi. If the air pressure at this point does not exceed the steam pressure, no air will pass into the retort during the come-up period; thus, "chatter" will not be controlled. Air circulation should be maintained continuously during the process and cool to ensure uniform temperature distribution and proper temperature and pressure control.

The amount of air required to prevent "chatter" during the come-up depends to a considerable extent on the steam pressure in the line and the back pressure in the steam distributor itself. The amount of air necessary may vary from 8 to 15 cfm. Further details on the amount of air required during this period can be obtained from a laboratory connected with the canning industry.

The amount of air required during the process and cool periods will vary with the size of the retort. Three (3) cfm is suggested for three (3) crate vertical retorts and four (4) cfm for four (4) crate vertical retorts. These requirements assume that there is no leakage from the retort either through the gasket or through the overflow valves. Air flow should be checked at regular intervals with a flow meter.

A check valve should be provided in the air supply line to prevent water from the retort getting into the system. An air supply line with hand operated valve connected to the head space of the retort may also be provided for auxiliary pressure control. *A separate compressor is recommended for operating the control instruments. If a separate compressor is not provided, the air line to the instruments should be a separate line from the compressed air tank.*

(15) Air Cleaners. The installation of an adequate air cleaner is required in the line which supplies air for activating control valves.

(16) *Cooling Water.* A check valve should be included in the cooling water line to prevent drop of pressure in the retort in case the water pressure should fall below the retort pressure.

a. *Vertical retorts.* Cooling water should be introduced at the top of the retort below the water level and above the jar level, either through a minimum of four openings equally spaced around the circumference of the retort or through a perforated ring. This recommendation assumes a feeder pipe of 1 inch minimum size with a minimum of 50 psi. water pressure at the retort. When water pressures of 80 psi. or over are encountered, the 1-inch line should be restricted or reduced to prevent excessive water flow rates or pressure during cooling.

b. *Horizontal retorts*. At the start of the cool, water should be introduced into the suction side of the pump so that the cold water can be mixed with the hot water to prevent breakage of jars from too sudden a change in temperature. Near the end of the cool, water can be admitted rapidly through the spreader in the top of the retort:

Retort Details

1. *Vertical retorts*. The general arrangement of a suitable vertical retort is given in the diagram (page 216). Details of the piping diagrams and specifications may be obtained from a laboratory connected with the canning industry.

Several specific details of vertical retorts require special emphasis:

a. *Door or lid-securing devices*. The retort lid should be provided with eight wing nuts or equivalent securing devices.

b. *Retort and crate diameters*. There should be a minimum of 1½ inch clearance between the side wall of the crate and the retort wall to allow ample water circulation up the retort wall. The inside diameter of the retort should be a nominal 42 inches and the outside diameter of the crates should be a nominal 38 inches. Not only should diametric clearance be provided, but centering guides should be installed to assure proper clearance between the side wall of the crate and the retort wall.

c. *Retort headspace*. A minimum of 4 inches headspace should be maintained between the top water level and the top of the retort shell.

2. *Horizontal retorts*. The general arrangement of a suitable horizontal retort is given in the diagram (page 215). Details of the piping diagrams and specifications may be obtained from a laboratory connected with the canning industry.

Several specific details of horizontal retorts require special emphasis:

a. *Water circulating system*. A water circulation system is suggested to ensure uniform heat distribution. This system should be installed in such a way that water will be drawn from the bottom of the retort through a suction manifold and discharged through a spreader which extends the full length of the top of the retort. The pump for this system should have sufficient capacity to circulate the retort contents every 4-5 minutes. The size of the suction manifold, circulating system, pump, and water spreader will depend on the size of the retort.

The following are suggestions for *minimum* sizes to be used:

For retorts under 15 feet in length

1. Size of suction manifold	2 inches
2. Number and size of suction outlets from retort to manifold	Two 1½-inch, equally spaced
3. Size of circulating line and pump	2 inches
4. Size of water spreader	2 inches

For retorts over 15 feet in length

1. Size of suction manifold	2½ inches
2. Number and size of suction outlets from retort to manifold	One 2-inch outlet for each 8 feet of retort length or fraction thereof
3. Size of circulating line and pump	2½ inches
4. Size of water spreader	2½ inches

The holes in the water spreader should be uniformly distributed and should have an aggregate area not greater than the cross-section area of the outlet line from the pump.

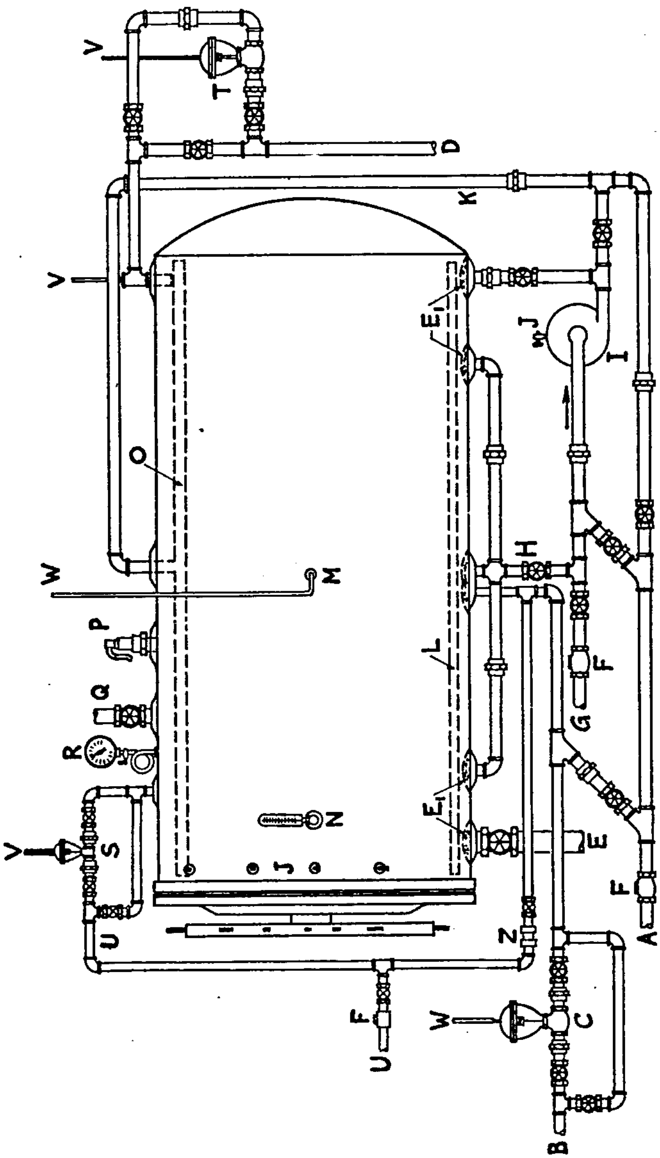
The suction outlets should be protected with a screen to keep debris from entering the circulating system, because such debris may foul the pump and clog the water spreader holes.

The pump should be equipped with a pilot light or other signaling device to warn the operator when it is not running, and with a bleeder to remove air when starting operations.

b. *Hot water supply.* It is advisable to have a hot water supply for filling retorts in order to reduce come-up times and avoid thermal shock. A steam heated storage tank equipped with temperature controller and thermometer should be provided into which hot water from cooling retorts can be discharged and saved for the next cook. The hot water outlet of the tank should be connected to the retort circulating system on the suction side, so that the circulating pump can be used to pump the water from the tank into the retort.

c. *Retort headspace.* The amount of headspace necessary varies with the diameter of the retort. In general, it may be said that the water level should not be above the bottom of the water spreader.

Horizontal Retorts

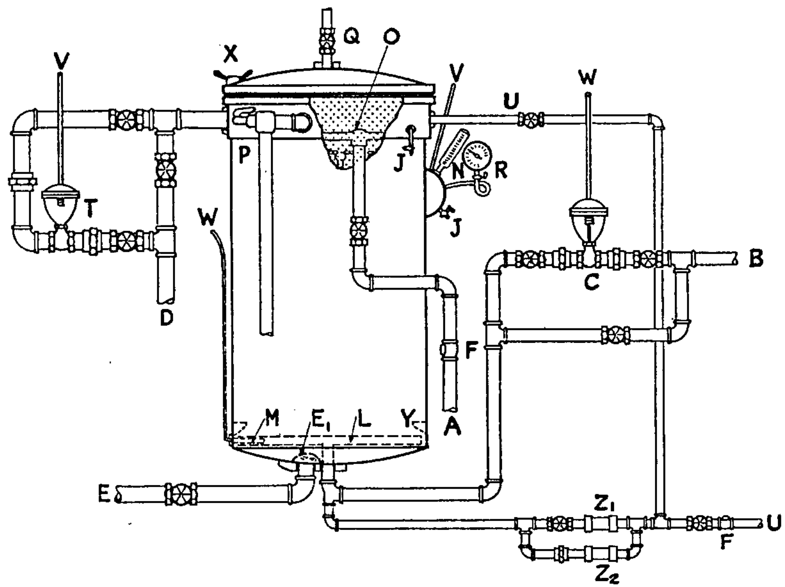


See explanation of terms page 216

Basic Requirements for Retorts Used in Processing Glass

A Water line
B Steam line
C Temperature control
D Overflow line
E Drain line
E_1 Screens
F Check Valves
G Line from hot water storage
H Suction line and manifold
I Circulating pump
J Petcocks
K Recirculating line
L Steam distributor
M Temperature controller bulb
N Thermometer
O Water spreader
P Safety valve
Q Vent valve
R Pressure guage
S Inlet air control
T Pressure control
U Air line
V To pressure control instrument
W To temperature control instrument
X Wing nuts—8 required
Y Crate support
Z_1 Constant flow orifice valve used during come-up
Z_2 Constant flow orifice valve used during cook

Vertical Retorts



Stacking Equipment

Crates, trays, gondolas, etc., for holding jars stacked in a vertical position should preferably be of strap iron or expanded metal. When perforated metal crates are used, the perforations in the bottom should be at least 1-inch holes on 1¾ inch centers, or their equivalent (3/8 inch on 9/16 inch centers, ½ inch on 1 inch centers, ¾ inch on 1½ inch centers, 1½ inch on 2½ inch centers, or 1¾ inch on 3 inch centers).

If divider plates are used between each layer of jars, they should be perforated as above. Plastic dividers reduce the potential for electrolytic reaction and abrasion with the closure during retorting.

Maintenance of Equipment

Processing equipment should be maintained in a satisfactory operating condition. The position and condition of the openings in the steam distribution system should be checked frequently to see that they have not changed. Safety valves should be tested frequently. Instruments (gauges, thermometers, recorders) should be tested for accuracy against a known accurate standard instrument upon installation and at least once a year thereafter or any time their accuracy is questioned. Water valves and compressed air valves, especially the latter, should be checked frequently for leaks.

Before each operating season and after any considerable idle period, the entire retort hook-up should be examined carefully, and each retort should be brought to processing temperature (without a load) to test the system for leaks, and air flow during the come-up time and processing cycles. The instruments and control equipment should be tested at this time for proper operation and accurate recording.

PROCEDURE

The glass containers indicated are those sealed with vacuum type metal closures, which are not intended to hold internal pressure. The processing of the closed jars is effected in water filled retorts, with a top cushion of air under pressure to hold the closures in hermetic seal throughout the retort cycle.

The headspace for most products should be not less than 6% of the container volume (measured at a sealing temperature of 130° F) for cooks in the range of 240° to 250° F. Unless the product temperature at time of sealing is very high, less headspace will not allow sufficient space for expansion of the contents of the sealed container and as a result the closure may be displaced.

For most products, the temperature at the time of sealing must be above 130°F. Lower sealing temperatures require larger headspaces to accommodate product expansion.

In general, retort operating pressure should be 20 to 32 psi. for cooks in the temperature range of 240-250°F. This depends on the type of closure used and the package conditions at the time of sealing.

Acidification

Unless some acidification procedure is followed, sterilization of certain low-acid foods by heat produces unmerchantable products. Notable examples are Globe artichokes, onions and green peppers. A health hazard is involved in the case of insufficient acidification. Under proper control such products may be acidified to the point where they are no longer low-acid and then may be processed in boiling water. However, this procedure should not be followed without consulting a laboratory connected with the canning industry. Experience has shown that careful supervision of all details, particularly the blanch, fill and brine, is essential when acidification is included in the processing procedure.

Coding

All containers should be coded by marks to identify the time of packing. The time period during which each code lot is packed should be as short as practicable–in no case longer than one shift. Strict adherence to this rule has proved to be good economy. Embossing code marks in metal closures is undesirable because of the possibility of corrosion. It is preferable that closure coding be done with ink.

For special container coding requirements that apply to low-acid foods see section on "Container Coding, on page 177.

Process

The term "process" as used in this section designates the heat treatment expressed in terms of temperature and time given the product after the container is sealed. The basic, or minimum, requirement for the process for any product is that it be sufficient to destroy *Clostridium botulinum*. This organism has the greatest known resistance to heat which, by reason of its survival, may be detrimental to health. There are other types of bacteria still more resistant to heat which may cause spoilage if the product is contaminated with them.

The efficiency of any process is dependent on the heat resistance and the number of contaminating bacteria in the product. In general, the processes listed in this book are regarded as adequate when something greater than an average number of spoilage organisms is present. In some cases contamination by spoilage bacteria may be so high and/or the bacteria of such great resistance to heat that the suggested process may be inadequate to prevent spoilage. It is therefore essential that all contamination be kept as low as possible.

Operation of Cook Room

In order to ensure that unprocessed or under processed jars do not reach the warehouse, it is recommended that:

(1) Processes for all products be posted in a conspicuous place near the retorts.

(2) All baskets, trucks, cars or crates containing unretorted material be plainly and conspicuously marked. If several products are being packed at the same time, each product should also be plainly indicated.

(3) A distinctive marker be hung from the retort opening when the retort holds unprocessed jars. It should be so placed that the door or lid cannot be closed before the marker is removed.

(4) A retort not be closed until the operator indicates that he is ready to start the process.
(5) Permanent time, temperature, and pressure records of every retort load processed be kept in daily process record cards.
(6) Jars of unknown status with regard to process, such as any found on the cook room floor, be opened and their contents discarded.
(7) Adequate precautions be taken to clear exhaust boxes and precookers of all jars at the end of each day's operations.
(8) Jars or retort crates be marked with a suitable heat indicating material that illustrates a change in appearance after exposure to processing temperatures.

Rapid Handling and Prompt Retorting of Filled Jars–A long holding period between filling and sealing or between sealing and retorting jars may result in souring, off-flavor, and loss of vacuum. Processing should follow within one-half hour after sealing. If longer times are required to obtain enough jars to fill a retort, processing of partial retort loads should be practiced.

Position of Jars in Retort–Heat penetration in canned foods containing freely flowing liquid is mainly by convection currents. The general trend of these currents is in a vertical direction, consequently in the product being heated they seek channels which permit such motion. Where their progress is impeded or baffled by solid material, the currents flow around the obstruction to the nearest point at which they can pass. For this reason the alignment of certain foods in the jar is of the greatest importance as regards heat penetration.

Where the packing or filling of any product in the jar results in stratification, the jars should be processed in such position that the plane of stratification is vertical. In the case of asparagus, for example, the spears are generally parallel and tightly packed in the jars in vertical position, so that the channels containing liquid are parallel to the spears. As a result, the speed of heat penetration is greater when the jars are placed upright in the retort. Except in special cases, jars should be processed in an upright position.

Stacking of Jars–Jars should be so stacked as to permit the free circulation of water throughout the retort load.

Retort crates should be made so they stack on each other and in no case should the top layer of jars extend above the rim of the crate.

Initial Temperature–The term "initial temperature" as used herein designates the average temperature of the jar contents at the time steam is turned on for the process. Just prior to the start of the process, the contents of the container used for checking the initial temperature should be shaken or stirred and the temperature determined. This container should be representative of the coldest jars in the retort load and should have an initial temperature equal to or greater than the initial temperature specified in this section. The specified initial temperature is to be regarded as a prerequisite minimum of the process suggested.

Where no initial temperature is specified in the tables, it is understood that this is not important between commercial limits such as 130-170°F.

Retort Cycle

In processing most products, the highest quality will result if the retort is brought to processing temperature quickly, the timing of the process is accurate, and the process is completed by prompt and rapid cooling. This procedure not only protects the quality of the product but also shortens the total time required for each processing cycle and so effects time economy in the use of the retort. It applies to all processing temperatures and is especially important when the temperature is above 240° F.

During the retort cycle there are a number of details that must be observed if reliable processing is to result.

Water Level. In vertical retorts the starting water level should be sufficient to cover the crates of filled jars as they are being loaded into the retort without a tendency to cause excessive overflow, yet bring the water level to the overflow pipe at the time of the loading of the last crate. The level of the water over the top layer of jars should be about 6 inches. No extra jars should be placed on the top of the last load, if they are not covered by at least this depth of water.

For efficient operation of horizontal retorts, the use of a reserve water storage tank is advised. As soon as the retort is closed, water should flow from the tank into the retort until the top layer of jars is covered by about 6 inches of water. The water temperature should be approximately that of the product in the jars at the time of sealing. Use of water at a substantially higher temperature may cause closures to be displaced. Water at substantially lower temperatures may cause breakage or reduce the initial temperature. *The water level must remain at approximately 6 inches above the top layer of jars during the entire come-up-time, cook, and cool.*

Many water supplies are of such character with respect to their mineral content that they require treatment to prevent unsightly deposits on the package and deleterious effects to the closure.

Water Temperature. The water temperature should be approximately that of the product in the jars at the time of sealing. Use of water at a substantially higher temperature may cause closures to be displaced. Water at substantially lower temperatures may cause breakage or reduce the initial temperature. To minimize thermal shock to the jars and to promote rapid heating efficiency as soon as the retort is closed, the temperature of the water should be adjusted by the introduction of water or steam to approximately that of the product in the filled jars. If the temperature of the water is more than 15° F above the sealing temperature of the jars, there is a possibility of displacing the closures.

Air Pressure. The air to the bottom of the retort must be turned on immediately after closing the retort and the over-riding pressure built up promptly to the operating range. The steam is then turned on. This pressure must be maintained throughout the come-up, process and cool.

Come-up Time. Timing of the process should not begin until the specified retort temperature has been reached on the mercury-in-glass thermometer. Agreement should be noted between the recording thermometer and the mercury thermometer, if not these should be tested and adjusted.

Cool. At the end of the specified process time the steam should be shut off and the necessary over-riding pressure maintained with air. The cooling procedures should be those specified on pages 212 and 213 of this section under numbers 14 and 16. Where a cooling canal is used to augment cooling in the retort the cooling should be continued under full retort pressure for sufficient length of time to produce some vacuum in every container. The duration of the water cooling period either in the retort alone or in combination with cooling canals or sprays should be sufficient to bring the temperature of the contents to an average of 100° F. Water cooling should not be continued to the point where external rusting of the container closure may occur.

Cooling water should be of potable quality and all cooling canal water should be chlorinated to a point where there is at least one part per million free available chlorine residual at the discharge end of the jar cooler.

Jar Dimensions

The jars sizes are given in the nomenclature usually employed in the industry, to avoid the confusion incident to conflicting local names.

In this system, the jars are identified by a statement of their dimensions (over-all diameter and over-all height). Each dimension is expressed as a number of three digits. The left-hand digit gives the number of whole inches, while the two right-hand digits give the additional fraction of the dimension expressed as sixteenths of an inch.

The first number given in the size of each jar is the diameter, and the second number is the height. For example, a No. 2½ jar, designated as 401 x 414, is 4 1/16 inches in diameter and 4 14/16 inches in height, that is, within manufacturing tolerances.

The characteristic of the common sizes of glass jars covered in the Process Tables are:

Container	Dimensions	Approx. Overflow Cap.–Fl. Oz.
Strained jar	200 x 309	5.1
No. 303 jar	303 x 411	17.0
No. 2½ jar	401 x 414	28.4

In those cases where the processes apply to jars other than those listed above, the dimensions are indicated under the respective process tables. If jars having capacities or dimensions not listed in the process table are used, consult a laboratory connected with the canning industry.

Precautions For Handling Glass Jars

Glass containers can be damaged by excessive mechanical or thermal shocks. It is suggested that lines be planned in cooperation with package suppliers to assist in obtaining the best container cooling system and method of handling. With modern high speed filling lines, particular attention should be directed toward eliminating:

1. Bruising jars by abrupt stops or careless handling.
2. Scuffing on conveyors or transfer points.
3. Excess thermal shock during filling processing or cooling.

The damage done to filled containers by impacts usually is greater than that to empty containers because of the added weight of the contents.

The hermetic seal of the friction closures applied to the jars can be maintained by careful attention to:

1. Maintenance of maximum filling temperature of product.
2. Adequate headspace in the glass jar.
3. Correct application of the closure.
4. Proper temperature of water during retort loading.
5. Ample over-riding pressure in retort during processing and particularly during cooling.
6. Proper heat distribution in the retort.
7. Provision for ample cooling after retorting.
8. Reasonable handling of jars during and after cooling.

PRECAUTIONS FOR SAFE RETORT OPERATIONS

Following is a summary of recommendations made by National Canners Association on steps and precautions for safe retort operation:

Important Points For Canners

1. *Comply with FDA Good Manufacturing Practices and Emergency Permit Control regulations.* Part 128.b and Part 90, Sub-Parts A and B, as they apply to each operation. Become familiar with equipment requirements, process filing, and supervisors training regulations. See section in this book on Food Laws, Regulations, and Standards.

2. *Follow approved procedures.* The procedures given in NCA bulletins are based on sound theory and wide practical experience. For safe processing it is important they be carefully followed.

3. *Keep your key men informed.* Irregularities in cookroom procedure, such as unprocessed cans getting into the warehouse, inadequate venting of retorts during coming-up period, and using a wrong process, will occur unless the cookroom is properly supervised. *Insist that all supervisory personnel and retort operators read this chapter* and understand the significance of the tasks they perform.

4. *Equip your retorts properly.* Tested and properly installed retort instruments are essential. Instruments need periodic testing.

5. *Don't reduce processes.* Processes in NCA Bulletins 26-L and 30-L give the highest quality consistent with safety.

6. *Code your cans.* The time period during which each code lot is packed should be as short as practicable—in no case longer than one shift.

7. *Maintain a record of the codes as cans move into distribution.*

8. *Keep your factory clean.* High bacterial contamination may lead to spoilage.

Important Points For Sterilization Equipment Operators

1. *Read carefully the entire introduction of NCA Bulletin 26-L* and Part 128.b of FDA GMP regulations in order that you may understand the significance of the tasks you perform. Retort and/or other sterilization systems supervisor(s) should also become well acquainted with the pertinent sections of the National Canners Association publication entitled "Canned Foods – Principles of Thermal Process Control and Container Closure Evaluation".

2. *Don't allow crates of cans to stand around* before processing. Spoilage may result.

3. *Don't trust your memory on processes.* Consult Bulletin 26-L or 30-L, of NCA.

4. *Keep retort instruments and valves in good working order.* Instruments need periodic testing.

5. *Vent retorts thoroughly.* Don't start timing process until temperature is up and pressure gauge and thermometer agree.

6. *Keep the retort temperature correct.* Timing the process is only part of the job.

7. *Keep permanent time and temperature records of every retort load processed.*

8. *Cool cans properly.* Too little cooling may cause either stackburn or spoilage; too much may cause rusting.

In order to minimize the possibility of mistakes and reduce the danger of unprocessed or underprocessed cans reaching the warehouse, it is recommended that the following cookroom operating procedures be used.

1. *Post processes for all products* being packed in a conspicuous place near the retorts.

2. *Mark plainly and conspicuously all baskets,* trucks, cars or crates containing unretorted material. If several products are being packed at the same time indicate each product plainly. The new GMP regulations require that packers of low-acid foods place a heat sensitive marker conspicuously in each retort basket, truck, car, or crate containing unretorted food product. Other effective visual indicators may be used instead of heat sensitive marker.

3. *Hang a distinctive marker from the retort opening when the retort holds unprocessed cans.* Place it so that the door or lid cannot be closed before the marker is removed.

4. *Do not close a retort until the operator indicates that he is ready to start the process.*

5. *Pick up, puncture, and throw out cans of unknown status* with regard to process found on the cookroom floor or any place in the cannery.

6. *Take adequate precautions to clear exhaust boxes,* precookers, and filled can washers of all cans at the end of each day's operations.

Retort No. ________: Cook Started ________ Time: Cook Finished ________ Time

Cook Card #____________________* Date____________________

STILL RETORT PROCESS RECORD

________PACKING CO.

Plant Location ____________________

Product ________________

Retort No.	Crate No.	Can Size	Code Top / Bottom	# Cans In Crate	Lot No.	
	Bottom					
	2					
	3					
	4					

Process Used-Time ________ min. Temp ________ °F.

Minimum Initial Temp. ________ °F.

Steam on ____________ Time AM — PM

Thermometer ________ °F. ________ Time (at end of vent period)

Retort Therm at ________ °F. ________ Time (Process Started)

Recorder at ________ °F. ________ Time

Steam off ____________ Time (Process Finished)

Process Time ________ minutes

Time Keeper ____________________________________

Management Rep ________________________________

Date ____________________

*List card number on process recorder chart

REPRESENTATIVE DAILY PROCESS RECORD FORM
FOR STILL RETORTS*

Product: (if form for single product)
Date:________________19________
Type of Container: (Tin, glass, etc.)

Company Name:________________
Plant Location:

Product (and/or Style of Pack)	Code	Retort No.	Container		Min. I.T. °F.	Time Steam On	Vent Closed	Time Temp. Up	Time Steam Off	Process		Thermometers		Recorder Chart No.
			Size	Approx. No. per Code			Time &/or Temp. °F.			Time	°F. Temp.	Mercury in Glass	Recorder Chart	

* Gives Information Required under GMP 128b.8

Note: Allow headings for critical factors, such as maximum drained weight and minimum net weight where applicable to scheduled process

Signed (or initialed) by
Operator or Designated Person:________________

FEDERAL REGULATIONS APPLICABLE TO STERILIZATION SYSTEMS FOR LOW-ACID CANNED FOODS

The recently issued FDA Good Manufacturing Practices regulations for low-acid canned foods, Part 128b, contain many requirements that apply to details of design and operation of several sterilization systems, in addition to still retorts. Canners are urged to consult those regulations and to comply with pertinent mandatory aspects. Those regulations were published in the Federal Register, January 24, 1973, on pages 2398 through 2410. Part 128b regulations are entitled "Thermally Processed Low-Acid Foods Packaged in Hermetically Sealed Containers." These regulations are also published in detail in *The Almanac of the Canning, Freezing, Preserving Industries,* published by E.E. Judge & Sons, Inc., Westminster, Md. 21157.

MALO CRATELESS RETORT SYSTEM

The vertical retort has grown in size, given up its crates, and become automated. The Malo system retorts are eight feet high and six feet in diameter. Their capacity is four to five times greater than the conventional three-basket vertical retort. With an automatic conveyor system one retort automatically top loads to the preset count for the particular can size, the conveyor gate closes and the next retort in line starts to load. Before loading starts the retort is half filled with water at the initial temperature desired. This water acts as a cushion for the cans falling through the 18-inch hole in the top. When the retort is loaded, the push-button operated hydraulic lid is closed.

Steam is admitted through a spreader at the top and forces the water out through the bottom. The water may be collected, reheated and used in another retort. The venting time necessary before the bottom drain is closed has been determined for individual installations. A representative venting procedure shown to be adequate is as follows:

(1) Open the top overflow valve, the bottom three inch drain, the bottom ½ inch bleeder and the 1/8 inch thermometer well bleeder; (2) Admit steam to the top of the retort through the regulator valve; (3) After two minutes, close the top overflow valve; (4) After all water is removed from the retort, as indicated by the ½ inch bottom bleeder, vent the retort through the fully open bottom three inch drain for at least four minutes and to a temperature of 230° F.; (5) Close the bottom drain, but leave the ½ inch bottom bleeder valve open throughout the process.

The bottom drain valve which acts also as a vent valve for this type of retort should be a quick-acting butterfly type valve. The drain line, which is usually three inches in size, should be connected to at least a six inch pipe manifold which opens to the atmosphere within a total length of 50 feet. The one-eight-inch bleeder in the thermometer and controller well must also be open during come-up and processing.

After processing the cooling water is brought in through the bottom and discharged through the overflow. After the cooling water is drained from the retort, the bottom door (39 inch diameter) which is hydraulically operated is partially opened, the cans fall onto a shaker screen and are then conveyed by belt to the unscrambler. All operations are by push-button from a control panel.

Advantages of this system reported by users are:

(1) The elimination of crates saves steam because they do not have to be heated; saves labor because they do not have to be filled, emptied and collected; reduces accidents; saves floor space.

(2) The water cushioning reduces can damage.

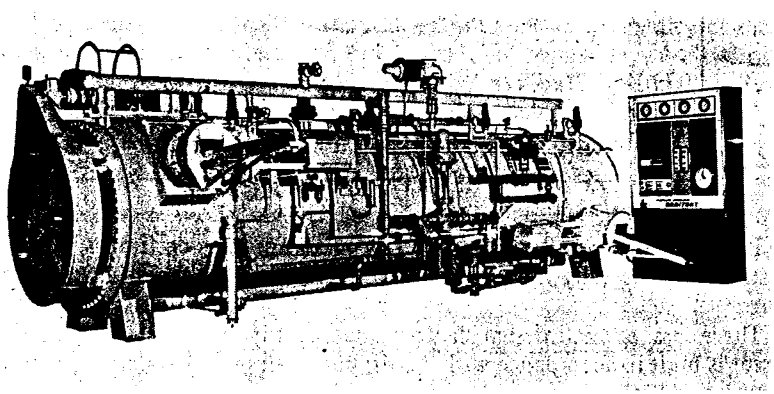
(3) Two men can do the work of eight with a conventional batch retort installation.

There has been some criticism regarding denting of cans in the unloading of the crateless retorts. This can be kept to a very low minimum, once the operator is familiar with what he is doing, to a point where denting is no greater than in conventional still retorts. The moving belt under the discharge has been found helpful in this respect.

FMC ORBITORT PRESSURE STERILIZER

The Orbitort is a high temperature-short time (HTST), agitating, fully automatic in-can sterilizer for canned foods. The Orbitort Sterilizer is designed for sterilizing viscous food products packed in institutional size cans, i.e., 603x600 and 603x700. Other can sizes may be processed if design changes are made in the machine at processor's request. The Orbitort has a capacity of 600 cans per cycle, a speed loading of 45 cans per minute, and a normal operating pressure of 25 psig of steam, with a maximum of 40 psig.

Products best suited for processing in the Orbitort are those that are too thick or viscous to heat and cool by natural convection methods. Examples are: cream-style corn, whole kernel vacuum pack corn, beef stew with vegetables, beans and sauce, creamed or chopped spinach, cut green beans, macaroni and cheese, puddings, and sauces.



FMC Orbitort Pressure Sterilizer
(Courtesy FMC Corporation)

Advantages

Reduced operating costs results from positive can handling which reduces can damage. Can control provided by a spiral and reel mechanism eliminates can-to-can contact during processing and reduces cost due to dented cans.

Better space utilization is another cost saving factor. One Orbitort Sterilizer occupying 290 sq. ft. can equal the production of up to eight two-can retorts, depending upon the product being processed.

Reduction of process times, up to 80% on certain products compared with still retorting, may be achieved. Induced agitation produces uniform processing throughout the can. Burn-on and caramelization of cream-style products, normally produced by still retort methods, is avoided. Process uniformity is assured; each can is processed exactly alike. Fig. 1 depicts how head space air bubble induces agitation in can contents during each revolution.

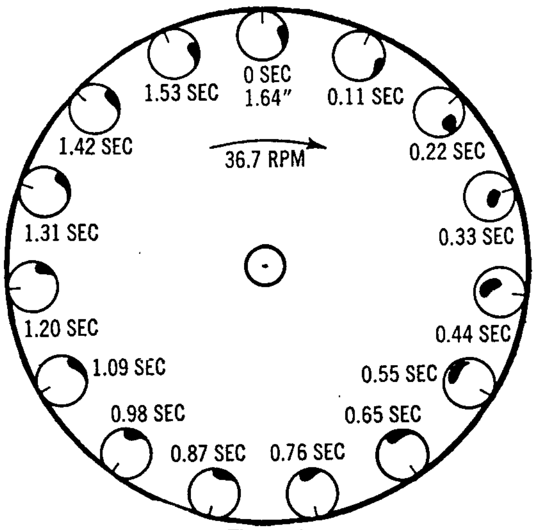


Figure 1

Orbitort Sterilizer Agitation

Diagram depicts how head space air bubble induces agitation in contents of cans during each revolution.

Labor costs are realized because automatic process control is provided. The processing cycle is fully automated, from initial venting and heating to complete cooling.

There are several design factors that greatly aid operational safety. The Sterilizer is built in accordance with ASME code. All piping systems are color coded according to ASME recommendations in order to indentify the systems and provide for safety of the operator.

Design and Operation Features

The Orbitort Sterilizer is a batch-type machine. Heating and cooling occur in one shell. Loading and discharging of cans is a simultaneous operation, but not a continuous one. During the processing period, the shell is sealed and pressurized.

The shell is of welded fire box steel construction to ASME codes, and the dished steel heads contain rollertype bearings to support the spiral-reel assembly. Two large, air-operated gate valves, for feeding and discharging, complete the pressure shell construction. Stainless steel tees and carbon steel angles are employed in the spiral-reel construction.

The spiral-reel assembly consists of an inner reel which carries flights that hold the cans as they are fed into the Sterilizer. The outer reel carries a spiral which causes the cans to move from the feed end of the Sterilizer to the discharge end. During the loading phase, the outer reel is locked to the shell, and inner reel is rotated to cause cans to move through the shell. While processing, the two reels are locked together to hold the cans.

During the loading phase, cans are released by an automatic can stop on the can track and rolled through the feed gate valve into the Sterilizer shell. Once in the shell, the cans enter the inner reel.

Loading continues automatically until the reel revolution counter and can stop counter indicate the proper number of cans have been loaded and held in the reel.

The complete processing sequence is controlled by an automatic digital programmer. This programmer is present to vent, heat, pressurize, sterilize, and cool the product. All steps are sequenced automatically and monitored by temperature, pressure, and elapsed-time controllers. This monitoring system assures uniformity of processing.

During processing, a recording controller records the retort temperature for permanent record. During cooling, an automatic level controller maintains the proper cooling water level.

When the product is cooled to the desired temperature, the programmer drains the shell of cooling water, stops the rotating reel, and indicates on the panel board that the unloading phase may proceed.

The unloading phase is carried out at the same time as the loading of the next batch of cans, but on the opposite end of the shell. The unloading valve is similar to the loading valve except it is located lower on the shell so the cans will roll out of the valve.

CONTINUOUS AGITATING PRESSURE COOKERS

Still retorts were used almost exclusively for low-acid foods until about 1950. Since then the agitating type of retort has become more common in the industry, resulting in considerably reduced processing times made possible by the higher rate of heat penetration into the food, and by the higher temperatures used. When processing relatively large packs, production costs are reduced through savings in labor as well as in steam, because there is no need for repeated venting procedures. It is possible to obtain in some instances, more product uniformity and higher quality, due to shorter processing time and to better control of time and temperature of sterilization and of cooling conditions. Can damage and product loss are also reduced.

The FMC Sterilmatic continuous agitating pressure cooker is made up of three units. The cans of food first go through a can warmer, then through the pressure cooker, and from the cooker to a pressurized cooler. The objective of using a pressurized cooler is to avoid the damage to can seams that a high internal can pressure would cause if the internal pressure was not countered by external pressure. Some systems use an atmospheric cooler following initial cooling in a pressure cooler.

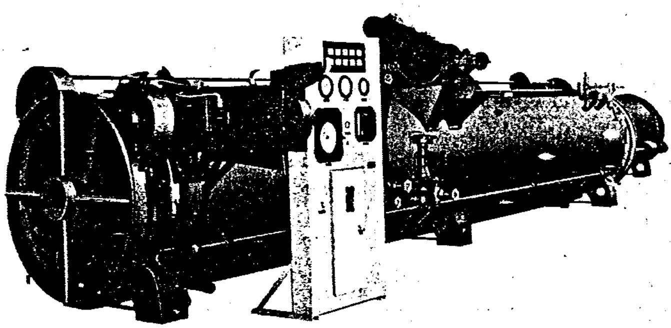
Continuous pressure cookers and coolers are built to take sealed cans from the closing machine and advance them through the shell in a spiral mechanism, subjecting them to steam under pressure which cooks and sterilizes the contents.

Design of the equipment manufactured by FMC Corporation employs principles of can agitation which materially affect processing time, temperature, and quality of the product. Each rotation of the reel produces a three-phase cycle:

1. A basting action is provided in the upper portion of the cycle. This is called the fixed reel travel, and the cans move about a central axis.

2. Agitation of the product within the cans occurs in the lower portion of the cycle, where the cans actually roll on the inner portion of the shell in free rotation.

3. Between these two cycles, the cans pass through transitional phases, where free-rolling agitation starts and stops.



"Sterilmatic" Continuous Pressure Cooker and Cooler
(Courtesy of FMC Corporation, Food Processing Machinery Division)

The three-phase rolling agitation is designed to provide relatively fast, even heat penetration, assuring a more uniform cook, as compared with still retort sterilization, or with non-agitating continuous cookers.

Newly developed models will operate at temperatures as high as 290°F and at speeds of 550 cans per minute for the 303 x 406 can size. FMC is providing a can warmer shell to the beverage industry which operates at a speed of greater than

1,000 CPM for 211 diameter cans. There is also a Sterilmatic unit that will process glass containers at the rate of 500 jars per minute.

Glass containers of 4, 6, or 8-oz capacity are loaded into cartridges automatically, passed through the cooker-cooler, and then are automatically removed from the cartridge. Aluminum end cans, aluminum body cans, and light weight steel cans are also being processed sucessfully in Sterilmatic continuous rotary cookers.

There is a cartridge adapter for cans or jars which operates at approximately 550 units per minute. It will accommodate sizes within a diameter range of ½ inch, and a length range of 1 inch. That is a combination ranging from the 211 x 300, to 300 x 401. Changeover time for can size will range from a few minutes to an hour; for a major product change up to a day.

The Sterilmatic uses .2 pounds of steam per pound of product, compared with .3 to .4 for the conventional cooker, and requires .3 gallons of cooling water per pound of product, compared with the conventional retort requirement of .6 gallons per pound. Container specifications are not demanding. The possibility of under sterilization is no greater than in other processes in general use. Control of head space and consistency is important. The caramelized or burned flavor is eliminated.

Continuous atmospheric cookers may be used for high acid foods, like tomatoes and fruits. The operation is followed by continuous atmospheric cooling.

ASEPTIC CANNING SYSTEMS

Aseptic Canning Systems have been developed to minimize quality changes that may occur in slow-heating foods processed in conventional retorting systems. Steam injection and scraped surface heat exchangers are used in aseptic systems to rapidly sterilize and cool food products before they are filled aseptically into sterile cans. Cream sauces, soups, and products containing rice, cheese or high tomato content are particularly improved by the high temperature–short time (HTST) processing used in the aseptic canning techniques.

With the Dole System it is possible to carry out simultaneous canning operations in a closed, inter- connected system as a continuous process. The several component operations are synchronized mechanically so that the product, containers, covers and finished canned product move through the system without interruption. The various temperature controllers and alarm system are included in the design of the equipment.

In the heat exchange systems used in conjunction with the Dole System, the liquid or semi-liquid food product is pumped continuously under pressure through the heating section of the sterilizer, in which it is quickly brought up to sterilization temperature (275° - 300° F), then through a holding section for the determined length of time to insure complete sterilization, and finally through a cooling section to the Dole Aseptic Canning System. The process temperature is automatically controlled by a controller-recorder type instrument. The process time is controlled by the rate of flow of the product through the system, which is maintained uniform by a product pump operating at constant speed.

The heat exchange system, in which the product is heated and held under pressure for the time necessary to complete sterilization, constitutes in effect a continuous-flow pressure cooker. Four general types of heat exchange equipment are presently used in conjunction with the Dole Aseptic Canning System. The steam injection type, the swept surface or scraper type, the tubular type, and the plate type. The type of exchanger utilized is in part determined by the nature of the product to be sterilized. Also, some exchanger types have inherent characteristics which to some extent limit their use.

For instance, the standard tubular exchanger requires cleaning at regular intervals to remove product which tends to build up on the tubing walls, but techniques are in use for cleaning in place with only brief interruption of the operation. The plate type exchanger has in the past possessed pressure limitations, but new designs on the market seem apparently to have corrected this limitation. The scraper or swept surface type depends on a rotor equipped with scraper blades to prevent the accumulation of product on the heat exchange surface and because of its basic design features has proved unusually effective especially with products of higher viscosity. The steam injection type of heat exchanger depends on the direct impingement of the steam into the product. The condensate may later be removed in a flash chamber which serves also as the cooling operation. This almost instantaneous heating method, either with evaporative cooling or when used in conjunction with one of the other types of exchangers performing as a cooling element, is in increasing use.

The heat exchanger does not differ in principle from the conventional "in-the-can" pressure cookers or retorts insofar as the lethal effect of time and temperature in the destruction of bacterial spores are concerned, but merely provides for the use of extremely short process times at high temperatures which cannot be realized by standard retort methods. The capability of the system to actually measure and control the process temperature and time eliminates the problem of any variations or fluctuations due to the heat–transfer properties of the product. This insures uniform product quality.

Sterilization of Cans

The cans (so-called sanitary type) are sterilized with super-heated steam as they are conveyed continuously through the can sterilizer to the filler. Steam temperatures in the range of 500°F are used to raise container temperatures to the neighborhood of 400°F in the sterilization period, a temperature safely below the melting point of low tin solder.

The temperature of the superheated steam is thermostatically controlled. At the same time the exposure of the cans to this steam is regulated by the speed at which they are conveyed through the sterilizer. The machine's unitized design means that multiple-section can sterilizers can be utilized to increase the speed of the system.

Sterilization of Covers

The covers are sterilized with superheated steam in a manner similar to that used to sterilize the cans. The cover sterilizer is attached to and operated as an accessory portion of the closing machine, mechanically separating the covers and transporting the covers through the sterilizer so as to expose all surfaces to superheated steam. Here again the temperature of the steam and the time of exposure of the covers are positively controlled and adjusted so as to provide a wide margin of safety against understerilization.

Aseptic Filling and Sealing Operations

Two filling devices, simple in principle and construction, are used primarily in the Dole Aseptic Canning System. One, a slit filter, has no moving parts. Empty cans pass under the slit opening of the filler with their flanges overlapped and a thin, continuous film of cold, sterile product from the heat exchanger feed line fills the cans. The other, a rotary multi-port filling nozzle, has several filling ports in line instead of a continuous slit, and contains a rotor with lobes so positioned that the ports are closed as the can flanges pass under them. The design of the multi-port filler permits the filling of heavy pastes and products containing discrete particles. Either filling nozzle may be used with fluid products. Both filler types depend upon a positive pumping rate of product for accuracy of fill. The cold sterile product, flowing continuously from the heat-exchanger, is filled into the sterile cans as they are conveyed from the can sterilizer through the filler.

An atmosphere of superheated steam or sterile gas is maintained in the filling section, closing machine, and interconnecting conveyor system to maintain sterility and to prevent the entry of airborn bacteria into the system. The continuous outward flow of superheated steam through joints and any other apertures in the equipment is a simple and effective safeguard against atmospheric contamination. The canning operations are carried out at substantially atmospheric pressure, thereby eliminating the use of complicated and expensive pressurized equipment.

The Dole Model 500 unit is capable of operating at speeds of 338 (211 x 400) cans per minute. The Model 700 does not operate rapidly (5 cpm) but the container holds about five gallons.

A second new machine in the development stage by the James Dole Engineering Corp. is the Model 800 which will handle 100 (7½ oz.) glass jars per minute. This unit uses pressurized steam at 60 psi (307° F) with an exposure time of 1½ to 2 seconds to sterilize the jars. Prior to this heat treatment a high vacuum is drawn on the jar and subsequent to the sterilizing cycle there is a pressure reduction when the sterile jar exits from the sterilizing turret, and enters into the super-heated steam area of the filling chamber. The capping machine's sterility is maintained in an atmosphere of superheated steam and the cap sterilizing turret utilizes pressurized steam (60 psi) for cap sterilization.

Summary of Products Packed by the Dole Aseptic Canning System

The Dole Aseptic Canning System is being used in an increasingly wide range of commercial operations. Although milk processors were among the first to recognize the merits of the system for canning milk and milk products, packers of other products—especially baby foods, soups, dessert puddings, custards, sour cream, dips and other heat-sensitive products—have turned to the system in increasing numbers.

Dairy Products

Dairy products sucessfully packed with the Dole System include whole milk, evaporated and concentrated milks, flavored milks and other dairy drinks, milk-based baby food formula, cream, butter and some types of cheese. Whole milk and concentrated milks processed by aseptic fill methods are now capable of being stored for extended periods of time and shipped without seriously affecting flavor or nutritive value. Progress made in recent years indicates that milk in more convenient form, such as sterile milk concentrate with fresh-tasting flavor and long shelf-life without refrigeration, will take on new significance in the dairy market in the future. The delicate flavor structure of milk products is much more faithfully preserved by the Dole System than by conventional retort methods which subject the product in the container to an extended heating period.

Other Food Products

With the substantial number of Dole installations in the field and the wide application of the system, an increasing number of food products is being commercially packed successfully. Heat sensitive products such as white sauce and hollandaise sauce, a broad range of soups, tomato paste, pear, peach and banana purees, baby foods and non-milk formula, meat purees and pet food, and many other standard and specialty items-all are packed advantageously by the Dole Aseptic Canning System. In fact, practically any product capable of being pumped through heat exchange equipment will posses quality improvement not afforded by conventional methods.

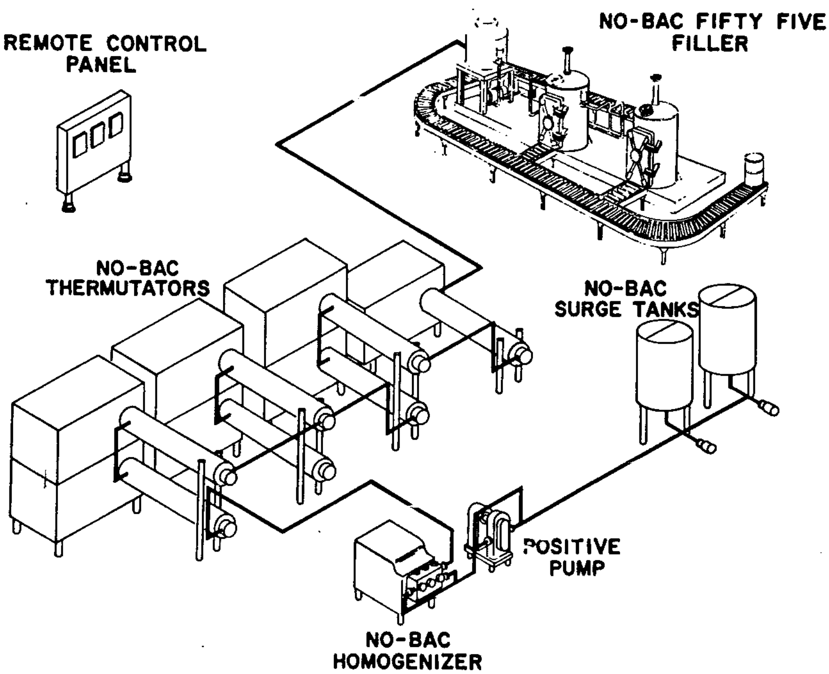
ASEPTIC DRUM FILLERS

No-Bac Fifty-Five Filler

The Cherry-Burrell Corporation No-Bac Fifty-Five Filler process consists basically in sterilizing a food product with pressurized steam to 60 psig at approximately 300°F, cooling the product under 20 to 26 in. of vacuum, and filling it also under vacuum into 55-gallon, electrolytically tin plated containers. The containers are made under a patented process by Rheem Manufacturing Co., and trademarked "Sterilpack" drums. The process is applied to pumpable food products, such as tomato, apricot, peach, and pear concentrates of different densities. Other fruit and vegetables concentrates and purees can also be handled and packed.

Operating sterilization temperatures assure a thermal treatment that will commerically sterilize both high-acid and low-acid foods. Product sterilization takes place in a heat exchanger. As product flows through the heat exchanger, product temperature is elevated to 220° to 300° F, depending upon pH of food. The more acid the product, the less it needs to be heated. After holding the food at the sterilization temperature for a prescribed period of time, it flows on to another heat exchanger where the food product is cooled to between 90° and 110° F. The cooled, sterile product is then held in a surge tank under minimum nitrogen pressure for transfer to pre-sterilized 55-gallon drums which hold over 500 pounds of the food concentrate.

The filling operation takes place in a retort. Containers are sterilized inside and out with pressurized steam at 100 psig. Filling is by weight, to about 1¼ in. headspace, under vacuum. While the filled drums are still in the retort, sterile, 4½ inch-diameter closures are swedged into the drums filling opening. Next, vacuum is released, and when the retort gauge pressure reaches zero, the door is opened. An interlock control system prevents sterile products from entering the Sterilpac 55-gallon drum until the sterilization cycle is satisfactorily completed, thus product, package, and sealing of drum cannot occur in other than an aseptic atmosphere. Vacuum filling in the retort, after the drum is sterilized, has the advantages of producing a slight evaporative cooling of the product and container, of making possible a more uniform fill, and of obtaining a uniform vacuum in the drum after closing. These features are positive factors in obtaining uniform product color, and in helping to prevent flavor changes and losses of nutritive value.



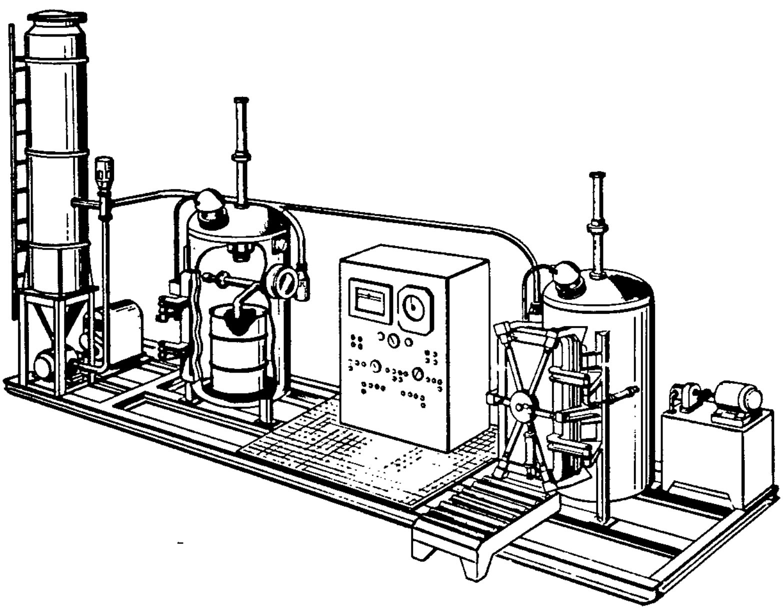
"No-Bac 55" Filler System
Used for aseptically (commercially sterile) filling foods in 55-gallon drums.
(Courtesy Cherry-Burrell Corporation)

The 55-gal Sterilpac drum has been specially designed. The body, top, and bottom of the container are made from electroplated 18-gauge steel. The thickness of the tin coating is 6 to 10 times that used generally for tin cans. The drum's side seam is welded during fabrication prior to plating. Top and bottom are double-seamed to the body at the container making plant. A 23 gauge electroplated cap seals off the 4½ inch opening in the center of the head through which the drum is filled. The drum withstands a vacuum of 27 inches. The interior may be coated with a sanitary lining. The actual capacity is between 57 and 58 gallons.

Several significant economic advantages are claimed for the "Sterilpac" Process, as follows: (1) improved product quality; (2) one drum replaces 75 No. 10 cans (603 x 700), which brings about lower handling and transportation costs as the product in drums occupies 26% less space; (3) 26% less warehouse space used; (4) direct labor saving, as only one container need be opened and emptied, instead of 75; (5) reduced product loss as one drum has 84% less surface area than 75 No. 10 cans; (6) empty drums are sold whereas empty cans involve an expense to dispose of them.

The remanufacturer gains access to the contents by cutting either end on the outside of the double seam with an electric tool permiting the end to be removed. Or the 4½ in. metal cap covering the fill opening in the center of the top head may be removed and the contents pumped out.

The idea for the "Sterilpac" Process originated with Rheem Manufacturing Company, of Linden, New Jersey. The processing and filling units were designed by Thermovac, Inc., of Stockton, Calif. At present, Cherry-Burrell Corp., of Cedar Rapids, Iowa, holds the patents for the process and is marketing a self-contained unit under the trade-mark "No-Bac Fifty-Five Filler". Capacity of the unit depends upon the product, with a rated capacity, for example, of 26 drums per hour of 32% solids tomato paste, weighing some 14,000 pounds. Four-drum retorts are available.



"No-Bac 55" Filler
Drum filling and sterilizing retorts with sterile product holding surge tank.
(Courtesy Cherry-Burrell Corp.)

Hambart Sterile Filler

The Hambart Sterile Filler has a capacity of 20 drums of 32 percent tomato paste per hour. The machine consists of two parallel tunnels each containing three sections which are enclosed and separated from each other by air operated vertical sliding steel doors. In the first section of each tunnel the 55-gallon drums are exposed to steam at atmospheric pressure to destroy acid-tolerant spoilage organisms.

The drum then moves to the second section, which contains two drums and atmospheric sterilization continues. The drums are then filled in a sterile atmosphere of steam at atmospheric pressure. The hot drums are filled alternately in one of the two parallel filling sections. The fill is controlled by the operator by observation through windows. The drums are then moved to the third section (fourth position) where the cap is swedged on. The drum moves out of the sterile section where it is weighed, stenciled, and palletized. A scale for weighing drums is included with this unit.

Fran Rica Drum Filler

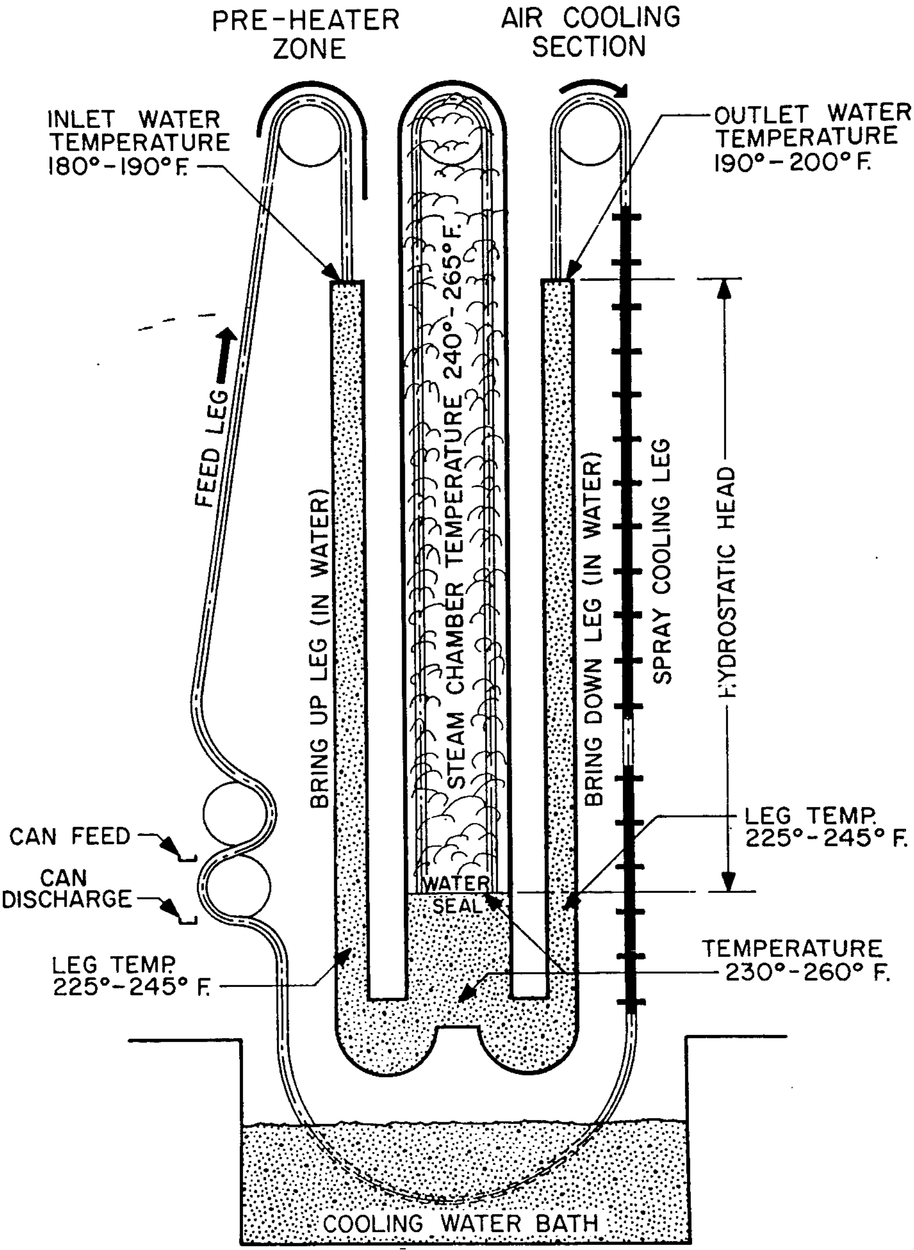
The Fran-Rica Drum Filler will automatically fill 15 drums per hour. The operator must put the empty drum into position and remove it after it has been filled. The top double seam of the drum is in contact with a gasket on the machine so that there is one complete chamber with the lid and inside of the drum as a part of the chamber.

The swedging toolpicks off the caps and moves back to one side, then the drum sterilizing nozzle goes down into the drum and steam at 15 pounds pressure is applied to the inside of the drum for one and one-half minutes with venting. The vents close and steam continues for an additional minute. The pressure is then reduced to one and one-half pounds and remains at this point for the remainder of the operation. The drum sterilizing nozzle retracts, and the fill tube enters the drum. The fill tube retracts at a signal from the product level sensor. The swedging head applies the cap, the drum drops down and is removed.

A filler for particulate products has been designed by Fran Rica Manufacturing Co., and built in conjunction with the Rheem Manufacturing Co. The sterilization equipment was designed and built by Fran Rica. The best description of the heat exchanger system is that it is a washboard surface which provides for a maximum surface on the smallest possible section.

HYDROSTATIC COOKERS

This sterilization method is more commonly known as "hydrostatic sterilization", because the steam pressure in these units is maintained by water pressure. Hydrostatic cookers are made up of water chamber and of steam chambers. The temperature of the water in the water chambers or legs varies from about 60°F to some 215° F. The temperature of the steam in the steam chamber is controlled by the pressure produced by the water legs, and it can be regulated by moving up or



Flow diagram of a hydrostatic sterilizer for canned foods.

down the overflow level in the downtraveling leg. Steam temperatures between 240° and 265°F are generally used. There are several models manufactured in this country and in Europe. Although the basic principle is the same, their design and the details, such as water and steam temperatures, vary greatly.

Basic Operation

The operation of hydrostatic cookers is basically as follows. The cans are conveyed through the machine by means of carriers connected to heavy duty chains which produce positive can travel control. The cans enter a water leg where the temperature is about 180°F. This is the down-traveling water leg, where the can temperature begins to increase. As the can moves down this leg, it encounters progressively hotter water. In the lower part of this leg the water temperature reaches some 215° F, and then, near the water seal area next to the steam chamber, the water temperature is about 225° F. In the steam chamber the can is exposed to a temperature in the range of 240° to 265° F, the steam temperature being set to suit the product undergoing sterilization. Some hydrostatic cookers have the can make two passes, one up and one down the steam chamber. Other models are designed for four or six passes. Upon leaving the steam chamber, the can again goes through a water seal into water at a temperature of some 225° where the cooling cycle commences. It is then conveyed through progressively cooler water to the top of the up-traveling water leg where the water temperature is between some 190° to 200° F. In other models the temperature of the water in the up-traveling leg is as low as 60° F, can cooling then being completed within this leg. One model of hydrostatic cooker with double feed has a maximum loading rate of 680 cans per minute of the 303 x 406 size, and another model has a capacity of over 800 cans per minute. Some hydrostatic cookers utilize multiple chains. This gives the added advantage of being able to process different can sizes at different process times.

In determining steam dome residence time, the temperature of both the inlet and the outlet legs must be specified.

Advantages and Disadvantages

The following advantages for hydrostats are claimed by the manufacturers:

(1) Savings in floor space.
(2) Large reduction steam and water costs because of regenerative heating and cooling.
(3) High capacity operation.
(4) Capability of processing all sizes of cans and bottles.
(5) Constant temperature operation. Steam flow is controlled by the water level in the water seal. A four-inch difference in water level equals 0.1°F temperature in the steam dome. Some units are also insulated.
(6) Hydrostats use less cooling water.
(7) The container is subjected to minimum thermal shock.
(8) The containers are handled gently because of the low chain speed (1-6 FPM).

(9) Low labor requirements.

(10) The brines in vegetables such as peas and beans are clear because of the absence of agitation.

The main disadvantages of the hydrostatic cookers are the impossibility of vigorously agitating the can and the very large capital investment required. Because of their very large size there is a considerable amount of structural steel required in their construction, and the installation costs are high. Comparing the hydrostatic sterilizers with continuous rotary cookers, it is said that the use of hydrostatic cookers is justified when the following conditions are encountered:

(1) The unit is operated the year round, preferably on a two-shift basis.

(2) The product is sensitive to high temperatures of processing. For example, if the product discolors when the cook temperature is higher than 245°F.

(3) The filler speed is at least 200 cans per minute on consumer sizes.

However, a direct comparison is very difficult because of the many factors involved. Continuous pressure cookers have a lower installed cost than the hydrostatic cookers, and also less maintenance because pressure cookers are simpler machines with less moving parts.

"FLASH 18" PROCESS

The outstanding characteristics of this continuous canning process are the filling of cans in a pressurized room under 18 pounds air pressure at a temperature of 255°F, the closing of the cans under the same conditions, and the elimination of retorting. The 18 pounds pressure and the fast food heating method used give the process its name, "Flash 18". Under normal atmospheric pressure, it is not possible to fill foods at a temperature above some 212°F. By raising the air pressure in the filling and can sealing room, the boiling temperature is raised and it is possible to fill cans at the sterilization temperature.

The following are the main steps included in the "Flash 18" process as they take place in the processing plant.

(1) Batches of food are prepared in steam jacketed kettles and partially cooked, as required. From here on the process is continuous.

(2) Food is pumped into a continuous stuffer. This is a feed pump for metering heavy slurries and heavy consistency food combinations. When normal consistency of the food is too thin, the batches fed to the stuffer are made up in concentrated form which are diluted to proper consistency by addition to sterile water or sterile sauce after heating to sterilizing temperature. The stuffer is a basic unit in the operation of the "Flash 18" process.

(3) From the stuffer the food moves on to the steam injector, which is a relatively long tube with a large number of steam injection points. Products of thicker consistency are heated in a scraped surface heat exchanger. The food is rapidly heated to 260°-270°F, held for 30-90 seconds, and then piped into the deaerator, in the pressurized room.

(4) In the deaerator a small amount of water vapor is evaporated, expelling with it air that was dispersed or dissolved in the food. Other volatile substances responsible in part for the "cooked" flavor of foods are also expelled. In the deaerator the food temperature drops some 5°F.

(5) From the deaerator the product is pumped to the filler, also located in the pressurized room. Clean but non-sterile cans to be filled enter and leave the filler on a conventional rotary track. Above each can on this track is a wide neck funnel which permits one-shot filling. Cans are thus filled with food evenly heated to 255°F.

(6) Filled cans are closed in a conventional steam-flow sealer, and conveyed to a "hold" tunnel. The total time from the moment the food reaches sterilizing temperature in the steam injector until the cans leave the "hold" tunnel is regulated so that the heat treatment is sufficient to properly sterilize the product.

(7) From the "hold"tunnel the cans move on to a cooling tunnel and are then transferred outside the pressurized room and given an additional cooling treatment by water sprays.

The main advantages of this process are said to be the continuous heating of the food without disintegration of the solid components; the brighter color and improved flavor; enhanced consistency and texture of foods; the elimination of "cooked" flavor from canned meats and vegetables; the one-shot filling into cans rather than metering-in first the solid components and then the brine or sauce, and the lack of requirements for presterilization of the cans.

Already commercially packed by this process are corned beef hash, chili with beans, beef stew, and other products. It is said that the process is also well adapted to the packing of other fancy casserole dishes such as beef Stroganoff, roasted half chicken in gravy, and steaks in mushroom sauce. Shelf-life of the products is reported as being very good.

One important basic advantage of the "Flash 18" process is the reduction in the time foods remain hot during processing. As cans are filled with food at the sterilization temperature, rate of heat penetration into the food is not a factor, and the filled and sealed cans need to remain a relatively short time at the sterilizing temperature.

Since the chamber containing the filling and closing machine is under 18 psi pressure, the operators must enter and exit through locks for compression and decompression. Employees work a four-hour shift including the time in the locks.

The main disadvantage of the process is the obvious large investment necessary. In addition, there is a licence fee for the right to use the process.

STERIFLAMME PROCESS

The "Steriflamme" process of canned food sterilization was developed in the late fifties in France by H. Cheftel, M. Beauvais and G. Thomas. Sales and manufacturing for U.S. and Canadian markets are handled by Filper Corporation, San Ramon, California.

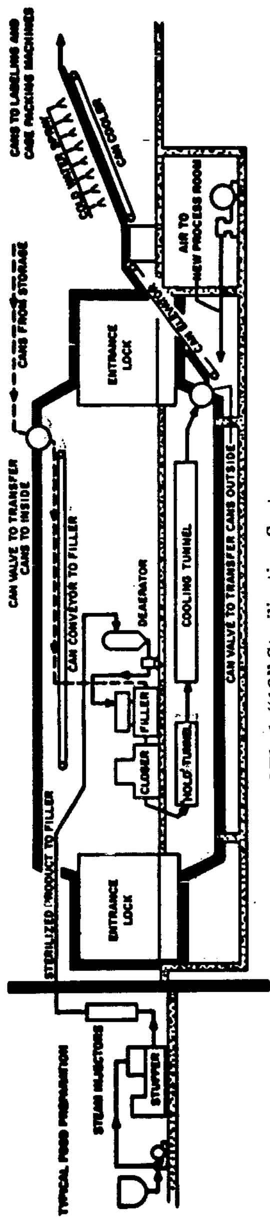
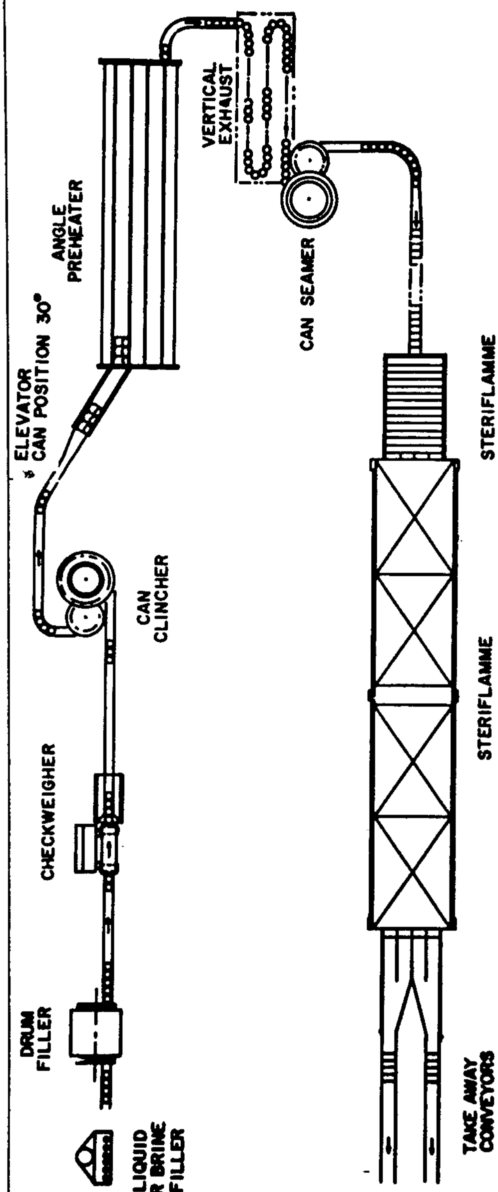


Diagram of Flash "18" Sterilization System



Vacuum and Steriflamme Flow Diagram

(Courtesy Filper Corp.)

The Steriflamme is a high-temperature, short-time process where cans of food, after being exhausted to 175°F and closed, are first preheated in steam, and then further heated by means of direct contact with flames, while rotating rapidly. After being held for the time necessary to insure sterilization, the cans are cooled by means of water sprays. A high vacuum is an important factor in preventing distortion of can seams. The process is suitable for foods that heat by convection, such as peas, corn, green beans, carrots, fruits, tomatoes and mushrooms. Equipment is available to sterilize one can size only, or three sizes at the same time. Unit cost and the short time required for sterilization make the Steriflamme worthy of consideration.

The Steriflamme unit consists basically of three sections. The first one is a steam preheater, where the cans are heated to a temperature of approximately 212°F. In the second section the cans roll through a series of open flames at 2,000°F produced by especially constructed gas burners. The rolling motion of the cans increases the rate of heat transfer into the whole mass of the food. Next the cans pass through an intermittently heated burner holding section for about four and one-half minutes. Spray cooling follows the heating cycle. The total elapsed time in the cooker is generally less than that required for batch retorting.

With appropriate products, the Steriflamme process insures about a 1°F raise in temperature for approximately every two seconds the can is rotating over and through the flames. The rate of heat penetration depends also upon the type and composition of the product, size of the can, and the rotating speed. Generally it takes about two minutes to raise the temperature of a can and its contents to a sterilization temperature of about 240°F. Because of the high rate of heat penetration, it is necessary to give special attention to the initial temperature, since a 1°F difference in initial temperature would reflect in a significantly different process lethality. One Steriflamme model provides an automatic control over the initial temperature by having the cans pre-heated in free-flowing steam to 212°F before entering the gas flames of the heating sections. Control of product temperature in the cans moving through the sterilizer is obtained by measuring the surface temperature of the can itself, as it has been observed that there is established an almost instantaneous equilibrium between the external surface temperature of the can and the can cold point.

An interesting aspect of the Steriflamme process is that, because of the high rate of heat penetration, the curve that indicates the rate of heat penetration into the product is a straight line when plotted in ordinary coordinates. It is not necessary therefore, to make use of semi-logarithmic graphs, and it has been possible to establish a graphic method to determine immediately the lethal value of the phase of the process that takes place over the open flames.

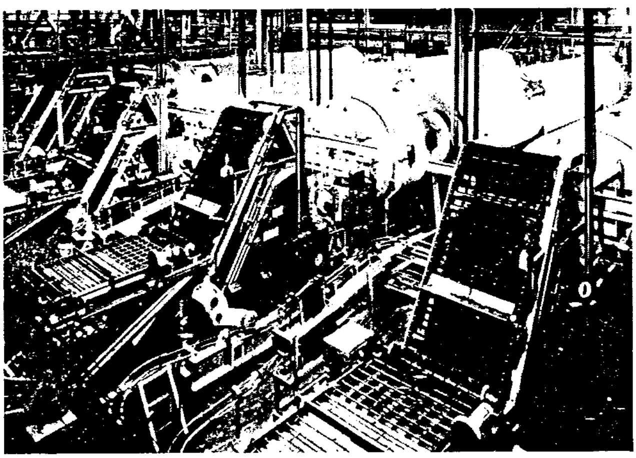
The sterilization of canned mushrooms in 4 oz. cans is an example of the time spent by the product in going through the different phases of the Steriflamme. Preheating in live steam, passage through flames, holding at 266°F, and cooling take each 3 minutes, or a total of 12 minutes for the sterilization process itself, including cooling. Tomatoes, 303 x 406, total time is 18 minutes, including cooling.

One obvious limitation of processes like Steriflamme in which the high internal can pressure is not balanced by an also high atmospheric pressure during sterilization is that the can seams may be weakened and then there is danger of recontamination of the product and therefore possibility of food spoilage. Dr. G. Thomas, one of the developers of the process, has recently investigated this point and reported that the conventional cans of U.S. manufacture can be flame-heated up to 255°-265°F if the can diameter does not exceed 307 and if the can vacuum is high. A development of high speed rotation (50 to 80 RPM) of the cans over flame has overcome this problem so that can diameter can now be 401.

HYDROLOCK

The Hydrolock is a continuous, agitating cooker/cooler for high speed short-term sterilization of a wide variety of sizes and shapes of containers. The system is applicable to the processing of cans, glass jars, semi-rigid plastic and metal containers and flexible pouches. It is also capable of processing plastic and metal containers with heat sealed closures. The Hydrolock is available through the Rexham Corporation.

Agitation is a continuous gentle rolling of the cans protruding through the bottom of the carriers and rolling on a fixed perforated stainless steel flat plate as the carrier progresses. The system is also available without agitation as determined by product and container configuration.



Hydrolock Continuous Cooker–Cooler System
(Courtesy of Rexham Corp., Packaging Machinery Division)

The basic parts of the Hydrolock system are:

A) *Waterlock* – The rotary paddle wheel waterlock permits the sterilization chain, connected carrier to enter the pressure vessel without loss of steam pressure and permits a controlled amount of existing water. Spring loaded sealing bars on each paddle are in direct contact with the stator to minimize water exit. The carriers (and cans) enter the system between the rotor paddles. The water which exits through the chain openings enters the atmospheric water leg and flows over a weir into a reservoir return line.

B) *Pressure Vessel* – Fabricated of carbon steel and manufactured as required by the provisions of the ASME Code Rules, Section VIII, Division I, for maximum allowable working pressure of 55 psi (3.87 kg/sq. cm) at a maximum temperature of 300 degrees F. (148.9 degrees C.). Sterilization takes place in the top portion of the pressure vessel and pressure cooling in the bottom portion in heated water, with the two areas being separated from each other by a steel plate, except for a portion to allow passage of carriers between sterilization and pressurized cooling.

C) *Chain-Carrier System* – Cans are automatically delivered from can lines to the chain carrier system which carries them through the cooker/cooler. The carriers, which are approximately 4 feet wide, hold cans stored end to end (height of can will determine number of cans in each carrier). The sterilization chain is a continuous chain which conveys the carriers and containers through the top side of the waterlock into the sterilization section of the cooker, through multiple passes in the vessel, and out of the pressurized water cooler section through the bottom side of the waterlock.

D) *Final Cooling* – Final product cooling is completed in two passes of atmospheric cooling below the pressure vessel. Cans roll in shallow water in stainless steel "pan" being pushed by stainless steel rods attached at their ends to roller chains.

The cooker can accept up to (6) different can lines simultaneously, each line introducing a different size can or product, with no changes required to the machine. After processing and cooling, discharge of each line is made into its respective labeling line. Production capability of the Hydrolock ranges from up to 200 per minute for No. 10 institutional size cans to up to 1000 per minute for retail (303) size cans.

The largest pressure vessel is 100 feet in length and has 8 roller chain-carrier passes, 7 in the sterilization section and one in the pressurized cooling water. The height of the system is approximately 12 feet, with the pressure vessel being approximately 8 feet in diameter The length of the vessel is ultimately determined by production output and product cook time.

Any heating medium can be used with the system:

Saturated steam, water or steam-air mixture. When an over-riding air pressure is required, as with glass containers, aluminum cans, plastic containers or flexible pouches, air is mixed with the steam by means of one or more turbo fans which produce a homogeneous mixture of the two gases.

Air overpressure is provided to preserve bottle and glass jar closure integrity during cooking and cooling. Total pressure is controlled by an automatic air inlet pressure control system which maintains a preset limit. Glass containers are carried in perforated stainless steel tubes which in turn are conveyed in a sterilization chain cradle carrier system. Tubular carriers are in contact with the fixed perforated stainless steel plate which causes the carriers to rotate within their cradles. This continuous rotation of the tubes results in agitation of the product. Jars enter and leave the tubes end-to-end. Cooling of the glass jars is done almost entirely under pressure. If further cooling is required it is completed out of the vessel in the same manner as cans.

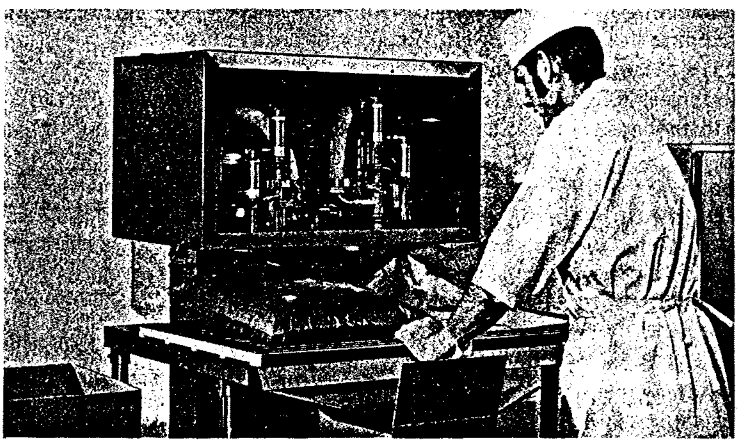
Heat penetration tests would be required to determine the manufacturing parameters of a Hydrolock. These tests would be conducted with the Hydrolock Simulator. This machine will exactly simulate any process for which the full scale Hydrolock is applicable.

"UN-DRUM" SYSTEM FOR ASEPTIC FILLING IN BAGS

The Scholle Corporation has developed a system for aseptically filling pre-sterilized food materials in plastic bags which are placed in corrugated boxes. It is reported that the system can be applied to aseptic packaging of fruits and fruit concentrates, syrups, pastes, flavors, vinegar, vegetable oils, water, and dairy products.

Basically the system operates as follows. Pre-sterilized, sealed bags are furnished the operator of the filler unit. While still sealed, the capped bag spout is inserted into the controlled, microbiologically "clean" atmosphere of the "Auto-Fill." The filler unit removes the cap, aseptically fills the bag through the spout, and recaps it, all automatically. The operator's hands never enter the "clean" chamber.

The system uses standard polyethylene liner bags or special barrier bags for oxygen and flavor protection. Both are available for packaging under either aseptic or non-aseptic conditions. The boxes are constructed of sturdy three-ply corrugated box material to effectively protect the liner bag, and to facilitate handling and storage in a minimum of space. For warehousing, four boxes can be stored and stacked on a pallet, up to four or five pallets high.



The "Un-Drum" System for Aseptic Filling in Bags
Courtesy Scholle Corporation

LABORATORY PROCESS SIMULATOR

The Laboratory Process Simulator is a development of FMC Corporation. The unit is used in research and development programs to determine heat penetration data for thermal sterilization processes and organoleptic characteristics of foods packaged in various types of containers.

The Model 1000 Laboratory Process Simulator has been constructed in such a manner that with suitable change parts, a number of different thermal sterilization and other heat treating processes can be simulated. Different size and shapes of containers such as retortable pouches, aluminum trays, and metal cans may be used in a wide range of process and equipment simulations.

The important simulations are the following:

Retort processing for pouches and trays using hot water with overriding air pressure (standard equipment).

Retort processing for pouches and trays using steam/air mixture (standard equipment).

Retort processing for pouches and trays with special agitating features (change parts required).

Vaporpac – a continuous filling and sealing system for pouches (change parts are required).

Super IT – a continuous system for trays – filling and sealing under pressure similar to Flash 18 (change parts required).

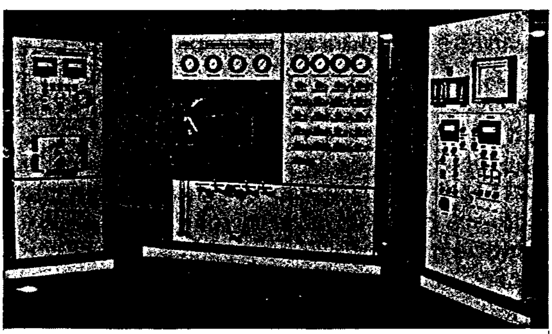
Hydrostatic sterilizer – a water leg pressure system for cans, pouches, or trays (standard equipment).

Containerized processing systems – a continuous, non-agitating system for wide range of container sizes and shapes (standard equipment).

Cartridge System – a continuous processing system for agitating or non-agitating cooks (change parts required).

Taylor Quick-Scan series 400 air operated transmitter type instruments are used for controlling processing temperatures and pressures in the range 100° to 300°F.

Thermocouples are used for recording processing vessel temperature as well as internal container temperatures and under certain conditions, internal container pressures. Recording is made with a Leeds and Northup 12 point potentiometer.



FMC Laboratory Process Simulator with Control Panels
(Courtesy FMC Corp.)

Ten points for copper-constantan thermocouples and two points for multivolt read-out for transducers.

A separate hot water storage tank is provided for water processing with air operated Taylor Quick Scan temperature controller with a range of 100° – 300°F.

The Model 1000-4 Laboratory Heat Sealer is used for sealing retortable aluminum trays or cups and is a complementary unit to the Laboratory Process Simulator. The heat sealing mechamism has been designed especially for laboratory work and provides an extra large platen for holding the large size dies for trays up to 24 cm W, by 29 cm L, by 6.3 cm H. This large size tray is the half steam table tray which is currently under study by a number of fo od processing companies. By changing the sealing dies, most of the common size trays may be heat sealed. The heat sealing unit has a separate control panel with automatic control instrument for heat sealing temperatures, time interval and seal pressures. The sealing unit is also provided with an enclosed housing making it possible to seal the containers under vacuum or completely vacuumizing the chamber and flushing with gas prior to sealing.

CHEMICAL STERILIZATION

Liquid Chemicals

The halogens such as chlorine in various forms have well-known microbicidal properties. One of the more widely held theories on the mechanism of cholorine's action is that hypochlorous acid formed by the reaction of chlorine and water penetrates the cell wall and attacks sulfhydryl groups. The various chlorine-based compounds have varying effects on different microorganisms, i.e.; although chlorine compounds are effective disinfectants and sanitizing agents, they do not necessarily guarantee sterility when spores are involved. Organic materials other than microorganisms react with chlorine compounds to reduce their available free chlorine which reacts with water to form hypochlorous acid. Besides questionable sporicidal action, the most significant problem with chlorine compounds is the well-known residual odor which can be readily transferred to food products being contained in packages treated with chlorine.

The basic limitation of most chemical agents is their lack of sporicidal activity. Chemical agents with known sporicidal capability are most frequently either toxic or require very long times – on the order of hours – to act. Thus, compounds such a formaldehyde which are good sporicidal agents are not desirable for sterilizing food packaging materials because of their residual toxicity.

In contrast, compounds such as hydrogen peroxide are oxidizing agents which produce active oxygen and water. The water promotes oxidative reactions. As a consequence, hydrogen peroxide can be considered as a microbicidal agent. All organic matter in contact with hydrogen and peroxide is also oxidized.

The use of hydrogen peroxide as a microbicidal agent is not common in medical or pharmaceutical practice because of the relative instability of the compound. On the other hand, its instability renders hydrogen peroxide relatively innocuous in contact with other than biological materials, and so it has been used to reduce the microbiological count of packaging materials. Hydrogen peroxide is the major chemical employed for microbiological destruction on plastic and plastic-coated paper being used for aseptic packaging. In bath form, hydrogen peroxide at elevated temperature is employed in the Mead/ERCA, SIGotherm and TetraPak Systems. In vapor form, hydrogen peroxide is employed in the Pure-Pak system to resterilize blanks that have been previously sterilized with ethylene oxide gas. The rationale is that ethylene oxide reduces the count to a low value and hydrogen peroxide performs the final killing. Hydrogen peroxide does not act on microorganisms that contain the enzyme catalase which breaks down hydrogen peroxide. Fortunately, anaerobic microorganisms do not contain catalase. Published test results indicate that 100% reduction in initial counts is possible by contact with hydrogen peroxide at room temperature.

The problem with hydrogen peroxide is not unlike the problem with other chemicals: selective activity, although the major organisms of consequence can be killed in reasonable time using hydrogen peroxide. Using hydrogen peroxide as a lethal agent on packaging as is being now done in commercial practice has carried with it a risk of microbiological survival when performed as suggested by packaging equipment or material suppliers. Future use of hydrogen peroxide as a sterilizing agent dictates full knowledge of all the conditions of sterilization. When that step is accomplished the use of hydrogen peroxide as a sterilizing agent might be totally acceptable.

Gases

Of the gaseous compounds that have microbicidal activity, most react not only with the organisms but also with both organic and inorganic materials. Among the more widely known gaseous microbicidal agents are chlorine, ozone, formaldehyde, ethylene oxide, and betapropiolactone. Ozone is unquestionably microbicidal and sporicidal, but it has highly oxidative ability. Chlorine gas in the presence of water vapor is almost as highly reactive as is ozone. Formaldehyde's microbicidal activity increased sharply at a 70% or above relative humidity, where the compound becomes highly corrosive.

The most widely used sterilizing gas is ethylene oxide, mainly because, like hydrogen peroxide, it damages very few materials. Ethylene oxide is both microbicidal and sporicidal, but its action is not rapid, requiring several hours at room temperature to act. Ethylene oxide's action is most pronounced at relative humidities of about 33% where inactivation of microbial spores follows a general exponential rate law. At relative humidity under 1%, or under high vacuum, the rate of destruction curve is similar to that obtained for thermal inactivation of a mixed culture. Desiccated spores have even greater resistance to this gas which appears to act upon the hydroxyl, carboxyl, sulfhydryl and amino groups in molecules.

The rate of microbial inactivation by ethylene oxide is also affected by gas concentration and temperature, with destruction rate appearing to rise by a factor of 2.7 for every 18°F rise in temperature. In normal commercial practice 120°F to 140°F is used. In practical applications, ethylene oxide concentration of 450 mg per liter is usually recommended as the minimum concentration that can sterilize within a reasonable time. The usual exposure time is about double that which would normally be suggested through pure culture testing. By increasing the concentration to about 1000 mg per liter, exposure time can be reduced by one-half, but above 1000 mg per liter, no appreciable time reduction has been noted.

Any factor which renders a material resistant to gas penetration can also reduce ethylene oxide's effectiveness. On the other hand, because ethylene oxide is a gas, it can permeate through apparently closed systems and act.

Although ethylene oxide is generally harmless to moist materials, mixtures of ethylene oxide and fluorinated hydrocarbons (used as carrier gasses) attack some plastics. Porous materials can absorb ethylene oxide, which is toxic, and considerable time (several hours) must be allowed foı desorption.

Etheylene oxide sterilization of spices has, however, been performed commercially for over thirty years. The same procedures have been employed to sterilize packaged packaging materials: enclosure in a pressure chamber and exposure to a mixture of about 12% ehtylene oxide: 88% halogenated hydrocarbon gas to provide an ethylene oxide concentration of 720 mg per liter for about two hours at 130°F, and 60-70% RH followed by a period of aeration to dissipate the gas.

Although ethylene oxide is widely used as a sterilization agent in hospital practice, relatively little is known about the interaction of ethylene oxide, carrier gases, moisture and many plastic materials. Much more needs to be learned about the presence of residual ethylene oxide on gas-sterilized materials despite the extensive experience with spices.

The most important element of the use of ethylene oxide sterilization in packaging materials does not lie with the sterilization procedure, but rather with the transfer of ethylene oxide-sterilized packaging materials into the area in which aseptic packaging is to occur without recontamination. It would be ideal if this gas could be used in continuous line with the packaging operation, but the requisite time period with present knowledge of the action of the gas precludes this possibility. Consequently, the heat-labile plastic packaging materials are packaged, sterilized, and aseptically transferred into the aseptic packaging area. Again a risk of re-entry of microorganisms is presented.

The recent use of beta-propiolactone as a gaseous sterilizing agent has evoked some interest, mainly because of this compound's more rapid action in vapor state at low concentrations. Relative humidities about 70% are required, and the compound must be presented in vapor state in equilibrium with the liquid. Beta-propiolactone is reported to be much more toxic than ethylene oxide. The major restriction of the use of beta propiolactone, which is being used in medical practice, is that so little is known about it, beyond the fact that it is an effective microbicidal agent which, when used very carefully, can be harmless to packaging materials.

Chemical agents are employed for sterilization of packaging materials that are heat sensitive in order to avoid heat damage. The major criteria that have been applied to determining the usefulness of chemical agents is their inertness to packaging materials and to any food subsequently contained should there be any residual.

The ideal chemical would destroy all microorganisms and spores in very brief time periods, would not react with packaging materials and would leave no residual. Obviously, the time required for ethylene oxide sterilization dictates that packaging materials sterilized by this method be transferred aseptically to another location, a risk-bearing procedures, or that packaging be performed in the sterilization chamber – which is awkward (but is performed for ice cream mix in at least two commercial aseptic systems).

To date, the closest approach to the ideal chemical sterilizer is hydrogen peroxide which gives promise of being able to be effective in-line against almost all microorganisms of consequence.

WAREHOUSING OF CANNED FOODS

There is almost every conceivable kind of warehouse and system of handling products to be found among canneries. Not all can be the best. Some are not nearly so good as they might be.

There are a few essentials which should be incorporated in every warehouse. There should be ample strength to carry the heavy loads which will be stacked upon the floors. Every precaution should be exercised to make it dry in order to prevent rusting of the cans and to have it reasonably cool. It should be frost proof and well lighted. Convenience of location with respect to the cook room and to shipping rarely escape attention as it affects labor costs and yet this is not more important than the other factors already mentioned.

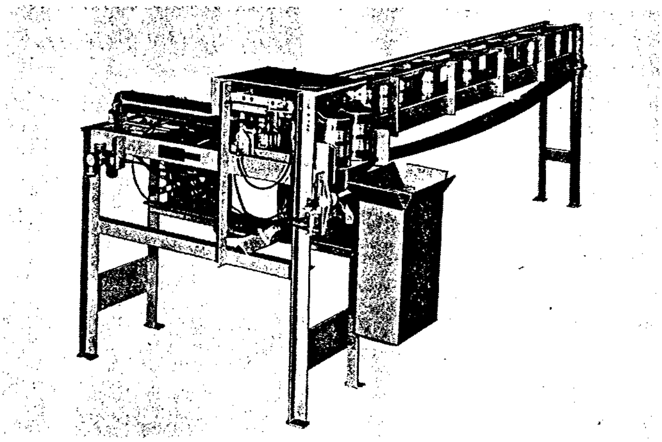
When plenty of land is available, it is customary to build warehouses only one story high in order to avoid costs of elevating loads. The warehouse usually has a flat metal or tar compound roof. This form of construction exposes the inside of the building more fully to outside temperatures. The stacks of cans become heated during the hot period and owing to their compact arrangement, they give up their heat slowly. In the case of a sudden drop in temperature as in freezing weather, the same flat roof chills the air on the inside and favors condensation of moisture on the cans. A second story for the storage of cans or other supplies affords some protection. In lieu of this, a hanging frame with sheeting below the roof will give a dead air space and act as an insulator. A space of from two to four feet will serve well, and be effective in both summer and winter.

In the event a hot water or steam heating system is used in a warehouse, an alley should intervene between the piles and stacks.

No cans or cases should be stacked on a cement floor, but upon wooden strips at least one inch thick. This is for protection against condensation of moisture of changes in temperature.

Stacking and Casing

Canning science and technology has progressed to the point where it is no longer necessary to stack cans in the finished products warehouse in such a manner that those that swell during a period of several weeks can be separated. The reliability of modern canning procedures makes it possible to case the finished product at the end of the canning line, or after a relatively short can cooling period if this is desirable depending upon the product being packed. Thus today most canned foods packed in this country are cased in shipping cartons after processing, cooling, and labeling, and placed in storage in the cartons. There are, however, some canners who prefer to store the cans in the warehouse uncased, and perform the casing operation at the time of labeling or shipping. Some store cans cased and unlabeled. Storing of uncased cans without labels is commonly done now in palletized form, with the cans placed on pallets after sterilization and cooling. This is called "bright stacking." Fork-lift trucks move the palletized cans to the warehouse. In other instances the sterilized and cooled cans may be mechanically conveyed to the warehouse where they are palletized and the pallets placed in position in the warehouse by means of a fork-lift truck.



Can Caser, Model 10, End Open, Non-Shock
(Courtesy FMC Corporation – Food Processing Machinery Division)

Palletizing

A pallet is essentially a shallow two-faced skid so constructed that the lifting arms of a fork or lift truck may be inserted between its faces, and pallet and load transported or stored as a single unit. Pallets have been constructed of a variety of materials, in varying design, and of different sizes. Pallets used in handling canned foods have been most commonly made of wood. Soft wood pallets are lighter and cheaper than those made of hard wood or heavy plywood, but they splinter and wear more quickly, require more maintenance, and do not last as long.

For palletizing unlabeled cans, the cans are piled directly on the pallets with heavy paper dividers between every other row to prevent slipping of the cans and shifting of the load. Cans palletized in this fashion may safely be stacked as high as cased canned foods on pallets. An occasional can suffers damage by dropping from outside rows, but the system effects a saving by eliminating the necessity of handling cartons when the cans are subsequently labeled. When the loaded pallet is tiered up in the storage block, the same precautions for even piling and correct placement of the load apply as for bulk piling of cased cans. Loaded pallets are usually tiered at least three high, and frequently four high, making a block twenty to thirty cases high. Training of lift truck drivers in the proper operation of the truck and correct tiering of loaded pallets is a factor in successful use of the system.

Speed of handling, savings in equipment, and man-hour economies have been cited as advantages of palletized handling of unit loads. When the principle is applied to the warehousing of canned foods, there are other factors that bear upon the economies and effectiveness of the system.

Savings of man hours of fifty to seventy-five per cent over older methods of individual unit handling have been reported for large volume receiving, storing, loading, and shipping of a wide variety of materials. Speed of handling, savings in demurrage and equipment, besides man-hour economies have been claimed. These economies are based on the fact that it is cheaper to handle in one movement a single load of many units than it is to handle each of the units singly. But when the principle is applied to the warehousing of canned foods, there are other circumstances which bear upon the effectiveness of the system and the economies that may be gained by its installation.

The primary fact is this: pallets are handling aids and must be used repetitively if benefit is to be gained from unit load handling. If pallets are used to hold canned foods in long storage, they actually become only an addition to floor cost and make that storage an expensive one. It has been suggested that palletized handling is uneconomical for storage that is dormant for periods longer than ninety days. Seasonal canners will not gain by the use of pallets for storing all of the season's pack, whereas year around packers who do not retail products in warehouse storage for long periods of time may benefit greatly. Pallet handling makes it easier to utilize all space in high roof one-story warehouses. In multiple-story warehouses where ceilings are lower and between-floor transport is required for some of the goods in storage, the system is impractical. Time studies of warehousing operations or even simpler step by step analyses and determination of labor requirements for the various warehousing tasks of transport, stacking, taking down, labeling, pallet loading and empty pallet handling and storage will reveal what savings are possible by adoption of unit load handling systems. Volume of goods handled, methods of labeling and casing, equipment investment necessary, and methods of shipping all influence the effectiveness of the unit load method. Frequently, combinations of continuous flow, or bulk storage, and unit load handling will be found most suited to the operation.

There are other uses for pallets in cannery warehouse operation than for handling cased cans only. Storage and transport of materials such as sugar, salt, starch, dry beans, or other bagged or packaged goods can be economically handled by a pallet system. Pallets are also used for efficient transport in receiving and dock handling of raw produce in lug boxes, crates and hampers, and for loading the empty containers for re-use.

When the loaded pallet is tiered up in the storage block, the same precautions for even piling and correct placement of the load apply as for bulk piling of cased cans. Loaded pallets are usually tiered at least three high and frequently four high, making a block twenty to thirty cases high. Training of lift truck drivers in the proper operation of the truck and correct tiering of loaded pallets is a factor in successful use of the system.

The unit load should be bound by cross-stacking of alternate layers in the same fashion used in making blocks in bulk piling of cased cans. Usually in palletized canned food handling the unit load weighs between 1500 and 3000 pounds. For shipment of unit loads, it is safer to strap, wire or glue the cases than to ship them loose on the pallets. The danger of loss by shifting of the load and resulting damage to cartons and cans is thereby minimized.

Warehousing of Uncased Cans

When cans are stored uncased and not palletized, small size cans are placed on their sides in large bins, while larger cans, such as No. 10, are stored upright, piled into large blocks.

The labor saving advantage of handling shelf size cans in warehousing operations in cartons rather than uncased is large and obvious. Small units which must be handled individually into and out of the warehouse stacks require much more labor than the same number of cans in cartons of 24, 36, or 48. Systems of storing cans uncased preclude the use of some types of automatic filled can handling equipment, such as boxers. The practice of storing filled cans uncased in bulk is being abandoned as basic labor costs rise and the availability of help for the type of tasks it requires decreases.

Some advantages are claimed for uncased storage but their practical value is dubious. The appearance of cases which have been used for storing cans in large stacks is perhaps not as good at the time of shipment as that of new cartons used for cans from uncased storage. This is more than off-set by the probability that cans stored in cartons will be cleaner than those stored uncased and unprotected from dust. There is no practical advantage with respect to saving of space, ease of inspection or lack of fibre carton insulation in uncased storage. In the event of leaking or bursting of cans during warehousing, uncased storage saves cartons, but exposes a larger number of cans to wetting and to the possibility of external corrosion and secondary spoilage through pitting.

One practice has been growing since the introduction of the agitating cooker and that is to roll the cans long distances to warehouses, and even to the points at which they are to be stacked. If the rolling be done at all, it should be very slowly as during the cooling period the strains are all inward and leaks can be developed which would never occur in a quiescent state. Moreover, a long, rapid roll of two hundred to four hundred feet while the product is warm will not aid its appearance. Economies in that direction can be carried too far.

Warehouse Temperature

Temperature is the most important variable condition of storage in the warehousing of canned foods. Qualitatively the beneficial effects of reduced temperatures have been recognized for a long time, but only a limited amount of quantitative information is available.

The chemical reactions which bring about changes in canned foods during storage are extremely complicated, but the principle applies that as the temperature rises, the speed of the reaction increases. It is generally assumed that the rate at which chemical reactions occur doubles with each 18°F rise in temperature. The importance of this assumption is evident when one considers the many ways by which chemical reactions may alter the flavor, texture, and nutritive value of canned foods. For example, chemical reactions occurring during 50°F storage will theoretically take place approximately twice as rapidly at 68°F and four times as rapidly at 86°F. The effect of storage temperature is often economically significant. In the example given, the variation in storage temperature between 50 deg. F and 86 deg. F may mean a four-fold difference in the rate of development of hydrogen springers, and therefore in the shelf life of cans containing products prone to this type of internal corrosion.

Temperature also is a governing factor in bacteriological changes which sometimes occur in canned products during storage. Because the influence of adverse storage temperatures may be evidenced in a variety of undesirable changes, accurate and consistent temperature control in cannery warehousing deserves serious consideration.

Internal corrosion results primarily from the action of the product on the metal of the can. Certain berries and high acid fruits are prone to liberate hydrogen and perforate the container by their corrosive action on the container walls. The effect of temperature is most apparent in its influence on the storage life of such foods in cans. Many other products attack the plate of the can less severely and storage temperature is important here also as it accelearates or retards the action and the resulting loss of vacuum. In some foods the action of product on can may result in the appearance of unsightly discoloration. This reaction likewise is speeded by high temperatures or retarded by low temperatures.

The quality of canned foods is perhaps not as sensitive to storage temperatures as are the reactions in which internal corrosion occurs. However, desirable texture, flavor and color are retained over long periods of storage at optimum temperatures. Excessively high temperatures may cause softening of texture, loss of fresh flavor and darkening of color in many canned products. Freezing has been found to have an adverse effect on the quality of canned foods containing a starch component. Separation of starch cells may cause the product to acquire a curdled appearance, and repeated freezing and thawing softens the texture of many canned foods.

The nutritive value of canned foods is maintained satisfactorily providing the storage temperatures are not excessively high. In a very general way, research in laboratory and plant has demonstrated: that storage temperatures between freezing and 50°F are optimum for preserving the vitamin content of canned foods, while temperatures above 90°F permit destruction of some of the vitamins originally in the product. Growing consumer interest in nutritional values of food makes consideration of methods for preserving these values in manufacture and storage increasingly important to canners.

Bacteriological changes also are influenced by temperature. In the growth of thermophilic, or heat-loving organisms, temperature is a governing factor. These organisms do not develop unless the temperature is within the proper range. For the thermophilic orgamisms which most commonly cause spoilage in the canning industry, this range is between 120°F and 150°F. The real necessity for control of storage temperature, at least in avoidance of this high thermophilic range, has been demonstrated often by thermophilic spoilage loss. Contamination of plants by thermophilic bacteria is difficult to avoid in the canning of some low-acid vegetables, and it is not unusual for thermophilic spore forming bacteria to survive in cans which have been processed according to commercially acceptable schedules. If storage temperatures are held below the thermophilic range these bacteria do not develop and loss can be avoided.

For retarding all chemical and bacteriological changes which are detrimental to the canned product, it is apparent that temperatures lower than those usually maintained in canned food warehouses are preferable. It is not practical to maintain warehouses of the type commonly used for canned food storage at 50°F temperature the year around. However, extremes of high and low temperatures should be avoided. Records of temperatures taken in surveys show extremes ranging from several degrees over 100°F in summer months to temperatures well below 32°F in northern areas in winter. Warehouse temperature is seldom the temperature of the food stored therein, since changes in warehouse temperature are very slowly reflected to the canned food in stacks, except for the first few outside rows. Cans cased at 95°F and stored in the center of large solid blocks may retain most of their heat for periods of months, even long after the warhouse temperature has become considerably lower. But it is necessary for reasons of avoiding external corrosion of case cans at temperatures high enough to permit rapid drying, and a minimum of 95°F is recommended. In this respect, palletized handling is advantageous since the large block of many pallet loads is better ventilated than the solid block of cased cans stored in bulk. Thorough ventilation and air circulation around stacks is necessary when newly processed cans are being placed in the warehouse.

External Can Corrosion

External corrosion of cans in storage may cause large losses to the warehouser. In slight degree, rusting means unslightly appearance of the can end or staining of the label. In severe cases, a totally unmerchantable package may result. Spoilage of the product because of rusting through the can from the outside may also occur. Several factors must be controlled within proper limits in order to avoid external rusting, and not the least of these are conditions prevailing in the warehouse while the cans are in storage.

The presence of moisture at the surface of the can is essential to rust formation, and the common phenomenon by which it gets there during storage is condensation from the surrounding air. In the industry this is called "sweating." It occurs only when the temperature of the can surface is at or below the dew point, that is, sufficiently colder than the surrounding air to condense moisture from it. When the relative humidity is high and the temperature of the cans is considerably lower than that of the surrounding air, conditions are optimum for sweating. The importance of dry warehouse atmosphere and constant even temperature is evident. Best conditions prevail when the canned products in storage are maintained at the same temperature as the surrounding atmosphere. Sudden increases in temperature and humidity, such as may occur on a warm spring day when a cool warehouse is opened to outside air, almost surely result in sweating. Proper heating, air circulation and ventilation around the stacks, and adequate temperature control minimize the danger.

The first step in the control of sweating is the measurement of the temperature of the cans and of the dew point. The determination of the dew point is not difficult. It is made with a psychrometer, which is an instrument utilizing the principle of cooling by evaporation to indicate relative humidity.

Sweating can occur during shipment of cannd foods from cool warehouses into warmer climates or storage space. Use of insulated trucks and freight cars and warming of cans before shipping help to avoid this trouble.

Condensation of moisture on cans in storage can result simply from excessive humidity in the warehouse atmosphere, and often it occurs where filled or empty can storage areas are above or near improperly ventilated cannery preparation or processing rooms, the latter should be well ventilated so as to take moisture laden air away from the warehoused goods.

Another of the common causes of external corrosion is not a condition of storage but rather of poor control of warehousing practice. This is the error of casing wet cans at temperatures sufficiently low that they do not dry quickly. Cans put into cases at temperatures much below 95°F stay wet for a considerable time, since the heat remaining in the cans is not sufficient to evaporate the moisture from the surface of the cans. The effect is aggravated when the cased cans are piled in the inner portions of large stacks, particularly if moisture repellant solid fibre cartons are used. Rusting can take place quickly under these circumstances. Mechanical removal of excess water from cans after cooling by air blasts, tipping of crates or other methods of draining help avoid getting excess amounts of water into the cases. But the surest method is to control cooling so that cans will be at the proper temperature when they are cased. The usual recommendation is that the average temperature of the contents of the can fall in the range of 95 to 100°F at the time of casing.

Several other less common conditions of storage may cause external corrosion. Seaside storage requires extra precaution in order to avoid rusting because of the extremely corrosive action of salt spray and the high humidities usual in coastal areas. Cans should be stored in tight dry cases, and warehouses built and ventilated so as to avoid as completely as possible having air currents from the ocean enter the storage space.

Acid fumes can contribute to rusting during storage. Their effect on stored cans should be considered in connection with the canning of sauerkraut, preparation of pickle brines, packaging of vinegar and manufacture of condiments containing vinegar. Severe corrosion can also result from contact of cans with corrosive dusts coincidental with high humidities. Among such materials are cement, lime and any chlorides, sulfates or acid salts. Particularly dangerous are hygroscopic dusts, which are dusts of material having the ability to absorb moisture from the air even at temperatures well above the dew point. Many chlorides have hygroscopic properties and if such dusts accumulate on cans, corrosion can be expected even when sweating has not occurred. Rusting of cans has also resulted from the use of damp fiberboard cases, and from packing cans in wooden cases made of green lumber. Several cases of external corrosion have occurred when wood having a moisture content higher than 15 per cent was used for making up the cases. Wood cases are not generally used in the U.S. anymore.

Corrosion Resulting from Cannery Operations

External corrosion frequently occurs during storage, not directly as a result of poor storage conditions but because of bad practice in various operations in canning. These factors are mentioned here because the corrosion they bring about frequently does not appear until after the cans have been warehoused, and because even when not severe they increase the possibility of extensive loss if the mistreated cans encounter adverse conditions during storage.

Retort operation can be the source of external corrosion of cans. Improper venting of steam retorts, carry-over from boilers of corrosive condensates in wet steam through improperly trapped lines, and contact of cans with rusty retort crates, especially in the presence of alkaline waters, all cause rusting, pitting, tin removal, or etching of the cans. The use of naturally corrosive waters for processing baths also is a cause of corrosion. Waters excessively acid or alkaline or high in chlorides, sulfates or iron are dangerous for such use. Water baths can cause corrosion from a build-up of product adhering to the outsides of cans which are not washed before processing.

Corrosive residues may be deposited on cans at a number of points in the canning operations. Failure to wash product from the outside of cans receiving no process, failure to rinse cans thoroughly after washing with alkaline detergents at the seamer, build-up of acid and salt dissolved in processing baths from the outsides of unwashed cans, and the use of cooling waters containing high concentrations of hygroscopic salts all result in the deposition of corrosive residues on the cans. Rusting may follow within a short time after the cans are warehoused.

Corrosive cooling waters of the same types considered hazardous for use in processing baths have often caused rusting of cans. Such waters may attack plate exposed by mishandling in previous operations, or they may initiate corrosion themselves. Where such corrosive water must be used in cannery operation, precautions can be taken to minimize the danger of their causing corrosion. Proper retort operation, the use of sodium chromate as a corrosion inhibitor in processing baths and cooling waters, spraying or dipping cans in soft or non-corrosive water after cooling, and control of cooling so cans will be cased at safe temperatures are all helpful in avoiding loss.

Abrasion of the tin coating through rough handling anywhere in the cannery invites rapid external rusting by exposing the base steel of the tin plate. Scratching or abrasion may occur in can runways and cable conveyors, unscramblers, boosters, casers, gravity drops, dividers, exhaust boxes, fillers, or at any place where the cans are handled.

The probability of loss through corrosion resulting from mishandling in the canning and processing operations can be minimized by close control of the conditions prevailing during the storage period. Constant temperature and low humidity are the most important requirements for safe rust-free storage.

Secondary Spoilage

Frequent inspection of canned foods in storage should be a routine part of warehouse operation. The early detection of any kind of spoilage frequently saves large losses resulting from secondary spoilage, which occurs when sound cans rust externally after being wet by leaking or burst spoiled cans. It has often been found in the investigation of spoilage discovered in goods stacked in warehouses and not immediately reconditioned, that the loss from seconday spoilage was far greater than that which resulted directly from the original spoilage itself. A dozen burst or leaking cans may eventually cause loss of hundreds of cases of canned foods. The leaking cans wet sound cans which rust through and leak onto many other cans, and the spoilage progresses almost geometrically. The development of this type of spoilage can be especially rapid where leaking occurs in stored cans of high-acid products. Storing of cans in small stacks in accessible location, frequent inspection and prompt reconditioning when spoilage is found will always keep potential spoilage loss at a minimum.

Effect of Freezing

Cool storage is desirable for all canned foods but they should not be allowed to freeze. Although there is no change in the nutritive value, color, or flavor due to freezing, the texture of certain products such as green beans and tomatoes is somewhat weakened. Canned products that contain starch, such as cream-style corn, squash, cream soups, cornbeef hash, etc., show a marked change in physical consistency due to freezing.

All of these products return to their original appearance and consistency on being heated.

Most canned foods show no effect due to freezing.

Light freezing has very little if any effect on cans. After thawing gradually they return to their normal shape with no appreciable loss of vacuum. Heavy freezing will likely burst the can seams. Other times freezing may cause distortion of the can seams without bursting them. Distorted seams may eventually produce leakers and spoilage.

If foods packed in glass containers are allowed to freeze solid, two things may occur. First, the jar may break, and second, the lid may come off due to the expansion of the contents. Although canned foods do not freeze quickly, all glass containers should be protected from freezing temperatures. Fruits packed in syrup freeze at a lower temperature than vegetables packed in brine. All freeze at temperatures below 32°F.

SPOILAGE OF CANNED FOODS

Swells

Swells are due to the production of gas by micro-organisms, either from lack of sterilization or by contamination through a leak. When any considerable number of cans swell soon after processing, without evidence of leakage, and the general run have a good vacuum, it is pretty safe to conclude that the trouble is due to under-sterilization. If one organism greatly predominates, grows under anaerobic conditions, and is spore bearing, it is strong confirmatory evidence that the trouble is due to lack of sterilization. Cans from the same lot, if placed in a warm temperature, generally develop some swells. Swells due to under-processing generally develop in a short time, within from two to fourteen days if the temperature is warm in the warehouse, but may be delayed for some months if held cold. The development of swells may also be slow in some heavy products like sweet potatoes, squash, pumpkin, heavy cream-style corn, and tightly packed spinach, so that the time element must be considered in connection with other factors.

There is an important biological differentiation between spoilage from under-sterilization and from leakage, as in the case of low-acid foods. In this group when spoilage occurs from under-sterilization it is due usually to a single spore-forming type. Where leakage is concerned, on the contrary, it is customary to find mixed cultures of nonsporing bacteria which could not have survived the process and which, therefore, must have entered the can after process. This differentiation does not exist in a clean-cut way in the case of the acid products because the aciduric organisms which cause spoilage may have been present in the product at the time of canning or may have entered subsequent to the process. Some guidance as to the cause of spoilage, however, may be had from observations as to whether spoilage occurred from one or a few or many bacterial types. In the latter instance leakage is indicated.

Swells may be so mild as to barely distend the ends of the can, or so strong as to cause the cans to burst. The gas is chiefly carbon dioxide although other malodorous gases may be mixed with it. The product is most often offensive, sour, and frequently more or less discolored.

The term "puffer" has the same significance as "swell" and is used more particularly among meat canners than among the canners of fruits or vegetables.

Swells are most often due to trying to hold the process to the minimum in time or temperature, and to changes in fill or consistency of the product without taking due account of the fact in the process room.

The words "flipper," "springer," "swell," etc., are used rather loosely by the canning trade. The National Canners Association's definition is: "Flippers" are cans, the ends of which are flat but one end of which is forced out when the can is knocked against a hard surface. Such cans, of course, have no vacuum and the ends may come out during shipping due to the dropping of cases during loading. A "springer" is a can, one or both ends of which are slightly bulged but the interior pressure of which is not sufficient to prevent forcing one or both ends to their normal position by means of pressure with the fingers. A "swell" is a can, both ends of which are bulged, and the ends of which cannot be forced to their normal position with the fingers.

A can, the contents of which are being spoiled by micro-organisms, passes through various stages. First, enough gas is produced to relieve the vacuum in the can, and at this stage the can may be a "flipper" as described above. When slightly more gas is produced the can may be a "springer" as described above, and later becomes a "swell." When the interior pressure is produced by hydrogen developing from the action of the acid of the product on the metal of the container, the same thing occurs. Sufficient hydrogen may be produced in time to cause the cans to burst, although this rarely occurs. However, many cans of fruits frequently contain sufficient hydrogen to become hard swells. Hydrogen swells generally can be differentiated from bacterial swells in that, whereas bacterial swells develop within about 15 days at warm warehouse temperatures, hydrogen swells do not become apparent until months after packing.

"Springers" from overfilling produced large losses for a time, but are of less frequent occurrence now. "Springers" due to insufficient vacuum occur in foods packed in a cool climate without proper exhaustion, and develop when the foods are sent to a warm climate or to a high altitude. They may develop at the same place during the summer of the following season. The means of correcting both of these faults is obvious. "Springers" due to the attack upon the metal by the food material have given much trouble. These usually develop slowly, requiring weeks or months, but may be hastened by storage in a warm place. The products most apt to cause "springers" are apples, cider, strawberries, sour cherries, loganberries and other seed berries. When a can is punctured, the gas emitted is hydrogen; it will burn on the application of a lighted match and there is no objectionable odor. The product is generally normal in appearance or may be somewhat bleached. The flavor is likely to have an astringency due to the iron. No bacteria are present. The product is sound but not merchantable.

Pinholing

Pinholing is caused by the same factors that cause hydrogen springers, but the action of the can, instead of being general is localized. These points are most often where the metal has been fractured by the die on the double seamer. In this case enamel lining aggravates the trouble, as fractures occur in the enamel and thus insure the maximum of chemical activity at those points.

Flat Sours

The "flat sour" is due to under-processing. The organisms present develop without the production of gas, but do produce a certain amount of acidity and thereby give rise to the name, flat sours. The exception is hominy—and there a sweetish taste is developed. The condition is caused by heat-resistant, thermophilic, sporeforming bacteria.

Flat sours generally occur when low acid foods, like vegetables and meats, are stacked in the warehouse while still hot. If cans are cooled after the sterilization process, the thermophilic bacteria that may have survived sterilization do not have enough time to grow and cause spoilage. Thermophilic bacteria grow only at temperatures well above those that generally prevail in canned food warehouses. There is nothing in the external appearance of the can to indicate that anything is wrong. Shaking may disclose a more or less liquid consistency with products like cream-style corn. If the cans are placed in warm water, the ends of those which contain flat sour material will generally be forced out more quickly than those containing sound food, and the reverse will follow on cooling. Advantage is taken of this fact to make a separation of the bad from the good cans. Flat sours occur in the interior of stacks of canned food and not in the outer rows of cans. The avoidance is the use of an adequate process, prompt cooling, and good sanitary conditions. Thorough washing of raw products to eliminate soil, and prevention of recontamination of product with soil or other sources of thermophilic bacteria during the canning operations is important.

Stack Burning

Stack burning is the result of storing cans while too warm. The contents soften, sometimes to the point of becoming soupy, darken in color, and acquire a disagreeable flavor. The cans look galvanized or of a dull color on the inside. Stack burning probably occurs more often in tomatoes than in any other product, due in part to the fact that tomatoes will not resist heat as well as most products, and to the further reason that they are packed in large quantities and stored at once. Due care is not taken to leave narrow ventilating aisles between the double tiers. Peas become mushy and acquire a scorched taste with the liquor dark and starchy. Other fruits and vegetables behave in a somewhat similar manner. Stack burning, like "flat sours," occurs on the inside of stacks and not in the outer rows.

Discoloration

Discoloration may be due to the effect of various metals, to the effect of high or prolonged temperature, and to bacterial action. The discoloration due to the first cause is the best known and gives the greatest concern.

Discoloration due to metals may occur from contamination before the foods are placed in the can or to a reaction between the food material and the container. Discoloration from without is well illustrated by the general blue-gray effect which occurs in corn when the machinery is first started in operation. Contact with copper at any point along the line of preparation, and particularly at the filling machine, causes darkening of grains and liquor. The same thing has been found to be a cause of blackening of peas so that free copper should be eliminated from the equipment by tinning the exposed parts or by other means. Blackening of hominy, however, is most often due to failure to remove the bleaching material rather than to the effect of the machinery.

The effect of iron upon fruits is such that no more iron is used in the preparatory apparatus than necessary. Fruit juices are so sensitive to metals that most of them form lakes, so that their preparation is best carried out in glass lined kettles, stainless steel or aluminum. All preparation tables should be of such material. The effect of tin is that of bleaching as far as it has any action at all. The effect of tin used in the can is no different from tin on any other vessel so that there is no logic in turning the contents out of the can into another tin vessel.

Black Stains

Discoloration from the action of the food upon the containers during processing is a source of much trouble. The temperature of the processing breaks up some of the sulphur compounds in the proteins and these combine with the iron forming the black sulphide of iron. This is especially objectionable in corn. A black deposit forms in the headspace of the can and more or less of it becomes detached and mixed with the corn. It has been made the subject of much study, but is now avoided by the use of special enamel lined cans. It occurs in canned shrimp, lobsters, crabs, white meats from fish, and the meats from the slaughter houses. It produces no harm except the objectionable appearance. The use of enamel lined cans for all such products has solved the difficulty. The can enamel known as "C" enamel was developed for this purpose.

The bleaching effect upon the foods, especially those which are highly colored, is also overcome in a large measure by the use of inside enameled tins. "R" enamel is used with highly colored fruits and other foods that are bleached by the tin which would otherwise dissolve from the can.

Discoloration due to heat is most often that of darkening though in the case of pears they turn a distinct pink color.

Discoloration due to a leak is always one of darkening. Discoloration from bacterial decomposition is rare, but is seen in peas, beans, corn, and fish products, and is almost invariably a blackening.

Glass-Like Deposits in Canned Foods

Canned food consumers complain occasionally of yellow crystals in asparagus, green beans, and onions; of white transparent crystals in grape products, and of crystals resembling particles of glass in canned crab meat, shrimp, and salmon. These crystals are completely harmless. They are formed by certain natural components of the food becoming too concentrated in a particular spot and then precipitating out of solution into the form of crystals.

The addition of substances known as "chelating agents" has been recommended to prevent the formation of these glass-like crystals in canned seafood products. Laws and regulations that apply to the manufacturing of these products must be checked before using any of these additives.

Off Flavors

Foreign flavors are most often acquired before the foods are placed in the cans. Vegetables acquire an acid taste due to incipient fermentation. They also develop a bitterness due to changes within their structure. This is more noticeable in asparagus than in any other product though it is not infrequent in corn and snap beans. Fruits, especially peaches and apricots, acquire a flavor from standing too long in pine lug boxes. It is difficult to describe but is referred to as piney, a slight suggestion of wood, turpentine, and resin. Fruits which stand in cold storage, take on a musty taste even though no evidence of mold be present. Standing in a close, unventilated room, either cold storage or not, develops a peculiar flavor believed to be due to the action of carbon dioxide.

SPOILAGE CONTAMINATION

It used to be assumed that the heat sterilization given canned foods killed all bacteria that might be present regardless of the kind of bacteria or the number of them. Researchers have shown that certain types of bacteria are very resistant to heat and that the presence of any considerable number of such bacteria renders successful processing very difficult. Furthermore, certain types of equipment or lack of proper control measures may permit such bacteria to multiply and become a spoilage hazard. The following statement on spoilage contamination is taken from the Appendix to Bulletin 26-L of the National Canners Association.

Precautions for Handling Filled and Sealed Cans

The installation of many of the new labor-saving devices for handling filled cans has introduced certain hazards which, if not minimized, may result in some spoilage even with the best possible double-seam construction. Before the cans are thoroughly cooled, the seams are slightly expanded and the compound lining is somewhat soft or plastic. In this condition cans are very susceptible to spoilage caused by rough handling. In addition to the usual attention to good seam construction, precautions must be taken in handling the cans before they are thoroughly cooled to prevent even small dents on or near the double-seams. When filled cans are handled in automatic equipment at high speeds small deformations of the seams may be more significant as spoilage factors than they are under slow speed, low-impact conditions. The three main factors in spoilage resulting from post processing can handling operations are: (1) the condition of the can double-seams, (2) the presence of bacterial contamination in cooling water or on wet can runways, and (3) can abuse due to poor operation or adjustment of the filled can handling equipment. The following recommendations will minimize the possibility of spoilage by recontamination following heat processing:

(1) Inspect can seams periodically to ensure that they are properly formed.

(2) Do not allow cans to drop into crates from the closing machine discharge tables without breaking their fall.

(3) Do not overfill the retort crates. This will eliminate protruding cans which could be crushed by the crate bales or by crates placed on top of them in the retort.

(4) Prevent sharp impacts between filled crates or against protruding points during transfer on the overhead monorail or on dollies.

(5) Operate crate dumps smoothly to prevent impact denting.

(6) Chlorinate all cooling water to a point where there is at least 0.5 ppm free chlorine residual at the *discharge end of the can cooler.*

(7) In pressure cooling cans exercise care to maintain adequate pressure for a time sufficient to prevent permanent distortion of the can ends. This may be evidenced by either buckles or straining of the double seam. *Pressure fluctuations must be avoided.*

(8) Periodically inspect the can handling system from the closing machine to the caser. Where rough handling of the can is apparent, smooth out the operation to minimize can seam damage.

(9) Dry the cans before discharge into the can handling system to lessen the recontamination hazard.

(10) When cans are handled on belt conveyors, lowerators or other belt elevators, construct these units so as to minimize contact by the belt with the double-seam, i.e., cans should not be rolled on the double-seam.

(11) Replace all worn and frayed belting, can retarders, cushions, etc., with new non-porous material.

(12) Thoroughly scrub and sanitize all tracks and belts which come into contact with the can seams at intervals frequent enough to prevent bacterial build-up.

General Sources and Control of Spoilage due to Contamination

The efficiency of any process depends in large measure upon the type and number of microorganisms in the product at the time of canning. All processes for low-acid canned foods recommended in this book are sufficient to destroy maximum numbers of *Clostridium botulinum* spores. There are spoilage organisms of non-health significance which are more heat resistant than *C. botulinum.* In general, the processes recommended in this book are regarded as adequate when something greater than an average number of spoilage organisms of non-health significance is present. The processes are not necessarily adequate in cases of extreme contamination by spoilage bacteria. This requires control of contamination by applying strict principles of sanitation and organized supervision and inspection.

Factory surveys to determine the identity of contamination sources and to develop means for their elimination have been conducted since 1926. The surveys have shown that the important sources of significant contamination with heat resistant spoilage organisms are located within the canning plant. Spoilage organisms come originally from the soil and are brought to the canning plant on the raw product. Preliminary washing operations are sufficient, with most products, to reduce this initial soil-borne contamination to a level which will not result in spoilage. However, residual spoilage types may seed the canning equipment and increase in numbers to a degree such that they constitute a spoilage hazard. There are exceptions, notably in the case of asparagus and mushrooms, where soil-borne contamination of the raw product may be a direct cause of spoilage.

Factory studies to date have centered chiefly upon the canning of asparagus, corn, mushrooms, peas, pumpkin, and spinach, but facts developed in these studies are applicable to other products. Accordingly, use of the following information should serve to control contamination to a degree that will ensure the effectiveness of the processes presented in this book.

Wooden equipment—In general, the use of wood in canning equipment is not recommended, because bacteria may become seeded in the pores and once established may contaminate food materials to such an extent that spoilage occurs with a process that has been satisfactory for years. Any wooden equipment with which food materials may come in contact, such as brine and hot water tanks, conveyors, blanchers, canning tables and even such small items as paddles and rollers, may act as carriers of contamination. For example, wooden tanks used for storage of hot water for general plant purposes may contaminate a whole canning system. Wooden brine tanks, at the beginning of a day's run, may supply large numbers of organisms to the product being canned. Owing to dilution their number decreases markedly during steady operation, only to build up again during a shutdown. Wood, being porous, is able to retain bacteria and hold them mechanically immune from scrubbing and other cleaning processes. "Seeding" may be prevented to a considerable degree by constant cleaning, but in spite of all that may be done, there is at present no practical treatment which will rid wood of organisms that are established in it.

Pumps. pipes, extractors, cyclones, etc.–Pumps, pipes, extracters, cyclones, etc., should be selected from the standpoint of ease in cleaning, because such equipment may hold food material that will serve as a medium for bacterial growth and permit the development of sufficient organsims to contaminate seriously the first part of the next day's pack. All such equipment should be thoroughly cleaned after being used, then thoroughly cooled with water and kept cool until next operated. It should likewise be flushed again with water immediately before it is used.

Care should be taken during the cleaning operation to blow steam through the perforations of steam distribution pipes which are submerged in food or brine during operation and to ensure that all perforations are open. Circulating "feeder" pipes should be thoroughly cleaned at the close of the day's pack. Preferably, they should be constructed so that they may be dismantled and cleaned with brushes. "Dead ends" should be eliminated or, if unavoidable, provided with drains so that they may be thoroughly flushed at frequent intervals. Pumps should be dismantled during the clean-up operation and only pumps which are adapted to daily cleaning should be used. Some person should be delegated to inspect all cleaning operations to ensure that this work is efficiently done.

Fluming–Flumes, such as those used for conveying peas and whole grain corn, may become sources of bacterial contamination. In particular, the use of water at temperatures in the range of 100°F to 180°F should be avoided since this may provide a favorable condition for the growth of thermophilic spoilage bacteria. The reuse of flume water when hot may aggravate the contamination. It is advisable to use only cold water for fluming purposes.

Fillers–Filling machines used with low-acid products have been found to be contaminated with spoilage bacteria. This contamination is usually the result of the filler being maintained at temperatures within the thermophilic growth range. This might occur during operation from contact with a heated product or during shutdown periods from leakage of steam supply valves.

Fillers should be dismantled and cleaned as frequently as practicable. After the day's clean-up, the fillers should be flushed with cold water with all machinery in motion to chill the equipment, and the fillers should be left clean, cold, and empty during the overnight shutdown. If the filler operates at temperatures within the thermophilic range during actual packing operations, it should be emptied of its product every 4 hours and thoroughly flushed with water with all machinery kept in motion.

Canning ingredients—In recent years there has been a growing appreciation of the importance, as carriers of spoilage contamination, of certain ingredients commonly used in canning. Among these are sugar, starch, flour, and dried milk.

SPECIFIC SOURCES OF SPOILAGE DUE TO CONTAMINATION

In addition to the preceding general information on sources of contamination, canners of certain products upon which extensive investigations have been made will find the following additional information and suggestions of value.

Corn

Preheating Systems, Mixing and Blending Tanks. The increasing use of mixing and blending equipment in which corn is handled while hot has demonstrated further need for contamination control. Such equipment while hot (180°F or higher) does not act as breeding points for spoilage bacteria, but when in the range 100°F to 180°F there is opportunity for development of thermophilic organisms. Usually this development occurs overnight and during shutdowns, and the spores which develop during those times serve subsequently to contaminate the run. As a rule, it is best to hold the tanks empty overnight. However, there appears to be no objection to holding them full of cold water provided care is taken to ensure that there are no leaky valves in the line which might tend to warm the equipment. Care should be taken during the cleaning operation to blow out perforated steam supply pipes; otherwise they may hold food material that will serve as a bacterial medium. Flushing and cooling may be accomplished conveniently by tapping a cold water line into the steam supply line adjacent to the mixer and blending tank.

Circulating Systems. Such systems represent another step in complexity from the preheating systems. The circulating feeder pipes should be thoroughly cleaned at night and preferably they should be constructed so that they may be dismantled and cleaned with brushes.

Whole Kernel Corn. With this product special care should be taken to prevent contact with wood equipment and, after being cut, the corn shoud be subjected to an efficient wash. The use of warm water or hot water in flotation washers should be avoided since such practice may lead to the rapid development of spoilage bacteria. Failure to wash the cut corn properly may result in spoilage.

Peas

The recommendations made with respect to control of blancher contamination in the canning of peas apply also to other products that are blanched in a conventional pea blancher such as lima beans and green and wax beans.

Blanchers. Both rotary drum blanchers and tubular blancher systems may become contaminated with thermophilic spoilage bacteria. The contamination which occurs during shut-down periods can be minimized by prompt cooling of the blanchers after use, by thorough cleaning, elimination of steam leaks, and flushing of the blancher system before its next use. However, thermophilic contamination may also occur during operation of either type of blancher system.

In rotary drum blanchers the contaminating bacteria are able to grow on the inner surfaces, above the water line, where temperatures are reduced by cool air drawn into the blanchers under loose-fitting doors and other openings. Any surface in the blancher where the temperature ranges between 100°F and 180°F can be the site of bacterial growth from which heat-resistant spores will be washed by condensate into the blanch water, and there contaminate the peas.

Efforts to prevent contamination in rotary drum blanchers should be directed toward elevating inner surface temperatures above 180°F. Blancher doors should be closed and fastened at all times. Doors which are bent or otherwise out of shape should be repaired in order to exclude as much cool air as possible. Vent stacks should be eliminated from the shell of the blancher. The coldest sections within a drum blancher are at the feed end. The use of a spray or steam jet, inserted at the upper edge of the feed end, which delivers steam or hot water (190°F or higher) over the inside surfaces has been found useful in preventing contamination. During operation the temperature of the blanch water should be as high as practicable (at least 180°F) and the reels should be kept in motion continuously while the blanchers are being heated or being held at operating temperature. A continuous overflow from the blancher should be maintained during operation.

The blancher water should be dumped as often as practicable since the number of bacterial spores in the water increases with time and use. The drain and water supply pipes should be of sufficient size to permit rapid draining and re-filling.

In tubular blanching systems a large percentage of the flat sour spore contamination occurs in the de-watering reel into which the peas are discharged from the blanchers. Thermophilic bacteria grow on the mesh of the screen and on the surface of the splash boards around the reel and the pan underneath. Spores produced by the bacteria are added to the peas as they pass through the reel or may be washed into the water and re-circulated in the blancher. This contamination can be reduced if sprays are installed to wash the surface of the reel with water which is preferably, but not necessarily, chlorinated. The use of cold water for this purpose is desirable to lower the temperature of the peas before they enter the quality grader. Sprays should also wash down the inner surfaces of the splash boards or canopy surrounding the reel. Tests have indicated that cold water is effective in reducing flat sour contamination when used in these sprays. The foam which accumulates on tanks supplying recovered water to tubular blanchers can be the growth site for thermophilic spoilage bacteria. A large, broad overflow should skim the surface of the tank. Top sprays delivering streams of water at a flat angle will help prevent the formation of foam and aid in skimming the tank.

It is important to wash the peas thoroughly after blanching. Adequate washing will remove large numbers of spoilage bacteria but cannot be depended upon to remove all of the bacteria added by a heavy contamination. Washing with cold water will reduce the temperature of the peas and thus help to minimize slime growth in subsequent equipment and prevent undesirable temperature increases in the quality grader brine.

Pumpkin

Practice in pumpkin canning is not standardized and the following suggestions are based upon a study of systems used by a majority of the pumpkin canners. Consideration of sources of contamination in pumpkin canning begins with the wilting equipment.

Wooden Box or Tower Wilters. As already noted, wooden equipment is objectionable, but it may be lined with metal if this is practicable.

Continuous Metal or Wooden Box Wilters. Both metal and wood boxes used as continuous wilters may be sources of contamination. They are difficult to clean and cool.

Continuous Conveyor Presses. There are various modifications in this type of equipment but the same principle is involved, that is, the pumpkin from the wilter is dropped into a hopper and carried between two moving belts. The distance between the belts gradually decreases toward the outlet end, and the pressure that is exerted squeezes the juice from the pumpkin. These presses are complicated mechanically and the parts vary in temperature. Where the temperature is favorable to thermophilic growth there may be some bacterial development. Some measure of control may be exerted by spraying the press "apron" with cold water, but this expedient is not fully satisfactory. From the viewpoint of contamination control the screw type press is much to be preferred. In this equipment the pumpkin is "wormed" through a tapering perforated screen. During operation, the temperature of all parts is so high (180° to 200°F) that no growth is possible. The screw press is readily accessible for cleaning.

Concentration of Pumpkin Juice. It is usual to discard the juice from the press, but in some cases the practice is to concentrate this juice and add it to the pumpkin at the finisher. This system is satisfactory when the general packing procedure is such as to keep contamination at a low level. However, the concentration of contamination is increased as the volume of juice is reduced by evaporation, and such contamination as may be present is returned to the product when the juice is not discarded.

Spinach

Washers. Spinach washers include "immersion," "spray-rotary" and "spray-belt" types. They are used singly, in multiple, and in various combinations. Their primary function is to remove grit and adhering soil and concurrently the soil-borne bacteria which are present. In all types of equipment, the washing efficiency is determined, at least in part, by the amount of water used. Thorough washing is of primary importance and a large volume of water is required. Washers should not be overloaded because this reduces their efficiency. When both immersion and spray types are used in the same line, better results are achieved if the immersion washer is placed before the spray washer. The first washing should always be done with cold water. The use of warm water in the first wash may lead to an increase in numbers of the bacteria that come from the field with the spinach, thus contaminating the equipment. Water should not be recirculated where a single washer is used.

Blanchers. Blanching equipment may be a source of spoilage bacteria, particularly those of the thermophilic group. To minimize the hazards of spoilage from this source, the washing and cooling treatments previously discussed should be applied. Occasionally rotary drum pea blanchers have been used, but since this type of equipment is difficult to clean there is opportunity for the development of spoilage organisms, resulting in continuous contamination of the spinach. Spoilage has been traced to such a blancher and its use is therefore not recommended. The blanch water should be renewed at a reasonably rapid rate.

CONSUMER COMPLAINTS

Practically speaking, at one time or another every canner is confronted with a consumer who found something wrong with a can of his product. It may be that in spite of close inspection a stone got into a can of peas or a stick was found in a can of spinach. Sometimes a carefully worded letter of explanation and regret with a few cans of the product sent from the canner direct to the consumer will settle the complaint. Once in a while, however, a suit will be filed and this may be very troublesome and costly. The National Canners Association provides a Consumer Complaint Service which handles such matters for its members. Some canners take out insurance with companies who make a specialty of such cases. Every canner should make some definite provision for handling any such case that may arise.

Those who use glass jars must insist on elaborate precautions to prevent any broken glass from getting into their products. If a jar is broken at the filler or the closing machine, *the entire assembly must be cleaned and inspected before operations are resumed.*

HOME AND INSTITUTIONAL CANNING

The formulas and the times and temperatures of sterilization given in this book are based upon large scale, commercial manufacturing operations. The book is essentially for use by commercial food processors, but it is possible to apply the directions to home canning, and to other small canning operations, such as community (school) canneries, penal institution canneries, and to canning done by groups of persons such as sportsmen and churches.

Care will be required in reducing the formulas to retain the same proportions, although all formulas are open to variations to meet particular tastes. In all cases these are basic formulas.

The home and the institutional canner must be mindful of the fact that canning on a smaller scale allows for no liberty to tamper with basic principles. Likewise, the same recommendations for times and temperatures of sterilization should be followed as for commercial canning, and the same rules of cleanliness and sanitation should be observed.

In the last few years there has been renewed interest in community and home canning. Those persons interested in obtaining specific details about recommended procedures for home and community canning may contact extension food technology specialists at state universities. The U.S. Department of Agriculture has issued several bulletins on home food preservation and on community cannery operation. Inquiries regarding equipment of size and design adequate for community and other institutional canning may be addressed to Dixie Canner Equipment Company, P.O. Box 1348, Athens, GA 30601.

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CHAPTER 2

INGREDIENTS

This chapter presents a discussion of basic properties, applications, and regulations pertaining to some of the main groups of ingredients used in the preparation of canned foods and of other processed foods.

FOOD ADDITIVES

Foods are made up of a mixture of chemicals put together by nature, but not all foods produced by nature are harmless. Some foods contain toxic substances. One example is the presence of oxalic acid in spinach and rhubarb. The presence of other toxic substances in certain species of mushrooms and berries are other examples. Even the most innocent substances, salt for example, can be harmful when used to excess. Then, again we have strichnine and arsenic compounds which are extremely toxic substances, but that in very small amounts are used for medicinal purposes. The criterion used as a guide here is not whether a food is or is not of natural origin, but whether the particular food has or does not have toxicant characteristics in the amounts used. The burden of the proof today is on the food processing firms or on the additive manufacturers.

To scientists and food technologists and, practically speaking, to the general public, a food additive is "a substance or a mixture of substances, other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage or packaging". These substances are frequently divided into two classes, (1) intentional additives, which are added on purpose to perform specific functions, and (2) incidental additives which, though they have no function in the finished food, become part of a food through some phase of agricultural production, or of processing, packaging or storage. According to this definition, chemicals such as sodium bicarbonate, citric acid, ascorbic acid (Vitamin C), thiamine, gelatin, and even common spices are considered additives, along with many more formidable sounding chemicals.

On the other hand, a lawyer must view the food additive as defined in the Food Additives Amendment to the Federal Food, Drug and Cosmetic Act. The definition of a food additive from the legislative point of view follows: "Any substance the intended use of which results, or may reasonably be expected to result, directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for any such use), if such substance is not generally recognized, (GRAS substances) among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures to be safe under the conditions of its intended use (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or experience based on common use in food)". In other words, the legal definition of food additives excludes most additives in common use because they are "generally recognized as safe" or because they have been previously approved for use. Other substances, such as pesticides and colors, are excluded because they are covered under other sections of the law. Thus, a food additive (to scientists and laymen) is not a food additive (to lawyers and legislators) when its use in a food has been approved according to the specifications of the Food Additives Amendment. For the purposes of this section we will use the laymen's definition.

Some additives are added to perform specific functions in the food products, such as to improve nutritive value, preserve the quality of the food, or to flavor or color the food. Other additives become part of the food product through some phase of fresh food production, processing, storage, or packaging. For example, an agricultural chemical applied to crops might be carried over into some processed foods, or a substance present in the food package might migrate into the food contained in that package. An example of the latter instance is calcium propionate used to control mold in bread or cheese by its activity in the bread wrapper. Additives such as agricultural chemicals, or substances that migrate from food packages may be present in foods, although usually only in minute amounts. Farmers and food processors, as well as federal and state public health authorities should all cooperate to make sure that these additives do not exceed safe limits. Food additives should be used in scientifically controlled amounts, not more than the amount necessary to perform the needed function, assuming that the amount has been found and declared safe by U.S. Food and Drug Administration.

Functions of Additives

Additives perform nine distinct functions:

1. *As Nutrition Supplements.* Vitamins, minerals, and amino acids used to improve general nutrition. Rickets have been practically eliminated in this country due to the widespread availability of vitamin D-fortified milk. Incidence of goiter has been reduced by the use of iodized salt. A general improvement in health standards can be traced to the supplementation of cereal products with thiamin, riboflavin, niacin, iron, and in some cases, with calcium and vitamin D. It has been estimated, for example, that enrichment of cereal foods alone provieds 12% to 23% of our daily supply of thiamine, niacin, and iron, and 10% of our riboflavin. Breakfast cereals combined with milk are, according to nutrition experts, nutritionally good foods.

2. *As Coloring Agents.* The natural coloring materials in foods may be intensified, modified, or stabilized by the addition of neutral coloring materials, or certified food dyes. While these chemicals alter only the appearance of food, they are important for the esthetic value they add and the psychological effect they have on our food consumption habits.

3. *As Preservatives.* Chemicals may be used to help prevent or retard microbiological spoilage and chemical deterioration. However, they must not disguise spoilage, deceive the consumer, or permit unsanitary food handling.

4. *As flavoring Agents.* In number, flavor additives probably exceed all other intentional chemical food additives combined; in volume, their use is small. All natural as well as synthetic flavors used in foods must first be approved as safe for health. The similarity of synthetic flavors to those produced in nature permits both types to be used freely in combination, with results not different from either used

alone. Flavor enhancers, which do not add flavors but instead intensify those already present, also require approval for use. Chemical enchancers were developed originally for commercial food processing. However, one such chemical, monosodium glutamate (MSG), has since found a market as a consumer product. The safety of MSG was reaffirmed by the National Academy of Sciences-National Research Council. However, since it was not found to benefit infants, NAC/NRC recommended that it not be used in infant foods.

5. *As Agents to Improve Functional Properties*. Chemicals in this classification act as thickening, firming, and maturing agents, or affect the colloidal properties of foods, such as in gelling, emulsifying, foaming, and suspending. Calcium salts, for example, help firm the texture of canned tomatoes.

6. *As Processing Aids*. Sanitizing agents, metal binding compounds, antifoaming agents, chemicals that prevent fermentation and chemicals that remove extraneous materials are grouped in this classification. Examples are silicones to prevent foam formation in wine fermentation, and citric acid to combine with metals and prevent oxidative rancidity.

7. *As Moisture-Content Controls*. Chemicals sometimes are used to increase or decrease the moisture content in food products. For instance, glycerine is approved for use in marshmallows as a humectant to retain soft texture. Calcium silicate is frequently added to table salt to prevent caking due to moisture in the air.

8. *As Acid-Alkaline Controls*. Various acids, alkalies and salts may be added to food to establish a desired pH. Phosphoric acid in soft drinks, and citrate salts in fruit jellies are examples of this chemical control of acid-alkaline balance.

9. *As Physiologic Activity Controls*. The additives in this group are usually added to fresh foods to serve as ripeners or antimetabolic agents. Examples of application for this purpose are ethylene, used to hasten the ripening of bananas; and maleic hydrazide, used to prevent potatoes from sprouting.

Safety of Additives

The safety of additives has been tested. One way this is done is through animal feeding experiments. These studies sometimes require two years or more, and may involve such experimental animals as rats, guinea pigs, and monkeys.

When all the studies are completed and the proposers of the new additive are convinced the additive will perform the needed function in food and that it is safe for its intended use, the research data are submitted to the U.S. Food and Drug Administration. Government scientists make a thorough examination of the research data with regard to the proposed use and safety of the additive. They approve or disapprove the use of the additive for the application requested, or they may request added information.

The concept of safety involves the question of whether a substance is hazardous to the health of man or animal. Safety requires proof of reasonable certainty that no harm will result from the proposed use of the additive. It does not and cannot require proof beyond any possible doubt that no harm will result under any conceivable circumstances. In determining safety, we must consider: (1) the quantity consumed of the additive; (2) any substances formed in the food because of the presence of the additive; (3) the cumulative effect of such additive in the diet of man or animals, taking into account any chemically or pharmacologically related substances in the diet; and (4) safety factors which in the opinion of experts qualified by scientific training and experience to evaluate the safety of food additives, are generally recognized as appropriate for the use of animal experimentation data.

When Additives Should Not Be Used

The use of additives is not in the best interest of the consumers and should not be permitted in the following situations:

1. To disguise the use of faulty processing and handling techniques, such as to reduce bacterial counts or to conceal off-odors.
2. To deceive the consumer, such as addition of color when its use has not been legally approved.
3. When the use of a food additive results in a substantial reduction of the nutritive value of the food.
4. When the desired effect can be obtained by good manufacturing practices which are economically feasible.

WATER

Water is in intimate contact with most foods during preparation and canning operations. It is universally used for washing fresh raw foods at various stages during preparation. It serves commonly as a carrier of raw materials between unit processes. It is the medium through which many unit processes, such as soaking, blanching, quality separation and preheating, are applied. It serves as an ingredient of formulation, or is the principal portion of the brine or syrup comprising the packing medium. Through its continuous contact with raw foods in preparation and canning, water exerts influence upon the efficiency of the cannery operation and upon the quality of the finished canned food.

The suitability of water for preparation and canning is measured by consideration of two general aspects of water quality. The bacterial content indicates its fitness for human use, and influences plant sanitation requirements. Its composition with respect to organic and inorganic impurities affects its use in cleaning, and may also affect the physical characteristics of the food being canned.

BACTERIAL CONTENT OF WATER

Potable water only should be used in the preparation of foods intended for human consumption. "Potable" water, by definition, contains no bacteria capable of causing human intestinal diseases, and is aesthetically satisfactory for drinking purposes, which means that it is free of undesirable odors and flavors. The fitness of water for drinking purposes, with reference to bacterial content, is measured by bacteriological examinations described in "Standard Methods of Water and Sewage Analysis," published by the American Public Health Association. These analyses determine the presence or absence of "coli" type organisms which indicate the probability of human or animal contamination of the water supply. State and local public health regulations invariably require that municipal or other public water sources meet A.P.H.A. standards for drinking water. Regulations governing cannery operations usually require similar adherence to the A.P.H.A. drinking water standards for water used in cannery preparation of foods intended for human consumption.

Although heat sterilized canned foods receive thermal processes more than sufficient to destroy all pathogenic or disease causing organisms, nevertheless, only potable water should be used in preparation and canning. In any food processing plant, the use of water which fails to meet public health standards also presents a possible health hazard to workers.

Municipal water supplies, which are usually purified, are safely free of coli contamination. Deep wells usually supply water which is potable with respect to its bacterial content. Shallow wells frequently are subject to contamination from surface drainage, and both shallow well water and surface waters almost always require purification to meet A.P.H.A. drinking water standards.

The total bacterial content of preparation and canning water, regardless of the type of organisms present, is an equally important consideration. It influences plant sanitation without bearing upon the public health aspects of canned foods. One of the purposes of washing food in preparation is to reduce its content of micro-organisms, and thereby prevent loss of quality prior to canning, and to help insure effective sterilization. Obviously, water used for this purpose should in itself have a low bacterial content. Water used for equipment cleaning, where contamination must be reduced or maintained at low levels, must likewise carry but few micro-organisms.

CANNERY WATER CHLORINATION

The most practical means presently available for insuring purity and low total bacterial content of cannery water is chlorination.

Recent years have seen widespread increase in the use of chlorine for treating cannery water supplies. Chlorination of the entire cannery water supply, commonly called "in-plant" chlorination, insures potable water for preparation and canning, and is an aid toward better plant sanitation. It is not a cure-all to replace sound plant cleaning practice and sanitary equipment operation, but *is* an effective means of promoting physical and chemical cleanliness.

Chlorination of the plant water supply contributes to better plant sanitation in several ways. Bacterial contamination is reduced, both in product and on equipment, wherever water containing free chlorine is used in preparation and canning. The deposition of organic materials from products being handled, and the growth of microorganisms thereon is largely eliminated by continuous chlorination. Odors developing from organic matter on belts, washers, flumes, other equipment, and on floors are prevented by adequate chlorination. The quality of the raw food products handled in preparation and canning equipment where water chlorination is practiced cannot fail to be affected favorably.

It has been the universal experience of processors that the use of chlorinated water for preparation and canning materially reduces the clean-up time required for good plant sanitation. It also has been reported that corrosion of canning equipment is reduced by water chlorination.

Experience and research adequately have demonstrated that in-plant chlorination has no adverse effect upon flavor and odor of canned foods washed, conveyed, blanched, or otherwise in contact with water during preparation and canning. However, water chlorinated up to 5 and 10 p.p.m. and used for syrup make-up has produced off-flavors in several canned fruits and in squash and sweet potatoes. When chlorine has been used in all other preparation and canning operations, but eliminated from syrup make-up water used for these products, no objectionable off-flavors have resulted.

Marginal chlorination means the addition of sufficient chlorine to water to satisfy partially the total chlorine demand of the water being treated. It is attained by adding sufficient chlorine to produce temporary chlorine residuals of somewhat less than 0.5 p.p.m., measured at a point in the water system usually not far beyond the point of addition. This treatment serves to destroy coli type organisms if their numbers in the water being treated are not excessive. However, because the chlorine demand of the water itself is not satisfied, the chlorine residuals produced in marginal treatment are dissipated quickly. There is then no available chlorine in the water at the point of its delivery in the preparation and canning lines, and the treatment has little effect upon bacterial development and therefore upon plant sanitation and product quality. Furthermore, impure waters may develop objectionable flavors when treated by marginal chlorination.

Break-point chlorination is the addition to water of more than sufficient chlorine to satisfy completely the total chlorine demand of the water being treated. This type of treatment produces and maintains free available chlorine residuals, and largely eliminates chloramines or other combined available chlorine residuals. The addition of chlorine beyond the amount required to satisfy the water's total chlorine demand—that is, beyond the break-point—merely increases the free chlorine residual in direct proportion to the amount added. Break-point chlorination usually eliminates the undesirable odors and flavors commonly associated with marginal chlorination, and supplies persisting free chlorine residuals. For these reasons it is the preferable treatment for preparation and canning water. During canning operations, in-plant chlorinating systems are ordinarily controlled to supply water having approximately 2-5 p.p.m. available free chlorine at the point of delivery to the canning line. During clean-up the chlorine level is frequently boosted to 10 or 20 p.p.m. or higher.

The two methods of water chlorination most commonly used in food plants involve the use of hypochlorite solutions or gaseous chlorine.

Gaseous chlorination is usually preferred for in-plant treatment.

Hypochlorite solutions are added through proportionating devices, and are sometimes used where chlorination of preparation and canning water is employed periodically. Equipment costs are relatively low in comparison with gaseous chlorinators, but hypochlorites are considerably more expensive as a source of chlorine than chlorine gas. Hypochlorinators require more constant attention for efficient operation, and are somewhat less versatile than gas chlorinators.

A recent development of in-plant chlorination for sanitation purposes and process water treatment is the availability of electrolytic generators that produce hypochlorite solution directly from weak salt brine. Such generators produce solution concentrations from a few ppm up to 6,000 ppm, with small capacity units employed for direct chlorination of equipment, floor, and wall surfaces, and large capacity units for continous chlorination of plant water supplies of processing water. The advantages of such equipment over the use of conventional chlorination compounds involve convenience, economy, and safety. There is no need to store unstable chlorinating compounds as hypochlorite is produced as required; solution pH is near neutrality which contributes to a more effective kill of organisms with less equipment corrosion than gas chlorine or alkaline hypochlorite compounds; and solutions do not give off irritating free chlorine gas.

Some precautions must be observed when in-plant chlorination is practiced. Excessive amount of free chlorine, due to its oxidizing activity, may result in corrosion of canning equipment, particularly if used in waters which of themselves display corrosive tendencies. However, water having an abnormally acid or alkaline reaction or a high concentration of corrosive salts is ordinarily not desirable for preparation and canning, and needs corrective treatment. Furthermore, the advantages of effective in-plant chlorination may be realized at levels where corrosion, due to chlorine activity, is not a danger.

It is most important to keep chlorinated water free of any contact with phenolic materials, because of the disagreeable and extremely penetrating nature of chlorophenolic flavors and odors.

Chlorination of Cooling Water

The cause-and-effect relation between the microbial population levels of water used for cooling cans after processing, and the rates of spoilage which may occur in those cans has been described many times. The canning industry has learned through experience that increased contamination of cooling water invariably brings about a proportional increase of product spoilage in cans cooled in such waters.

During the period when cans are being cooled after processing they are somewhat susceptible to the ingress of spoilage bacteria, even when the can structure is normal in every respect. At the end of the process the can seams may be slightly distorted as a result of the heat and strain of the process, and the sealing material is in a softened condition. In an effective cooling system, the internal pressure developed during processing is dissipated and a partial vacuum is formed before the cans leave the cooling water. At this point, seams of some cans may admit minute amounts of the medium in which the cans rest. The material which may be admitted is immeasurably small and has no effect upon can vacuum, and yet it may bear several viable bacteria which can initiate spoilage. The probability that one living micro-organism may gain ingress into a sound double seamed can in this manner becomes greater as the contamination level of the cooling medium increases.

Laboratory experiments and plant experience have demonstrated that the degree of spoilage of processed cans increases as the numbers of bacteria in the cooling water increase. Ideally, cooling water should meet Public Health standards for total bacterial count, and in many canneries where effective chlorination is practiced, cooling water does approach such standards. However, in plants where chlorination of cooling water is not practiced, bacteria counts greatly in excess of these limits are often encountered. Evidence obtained in controlled plant and laboratory work, indicates that cans cooled in water containing over 100,000 bacteria per cubic centimeter exhibit rates of spoilage five to ten times greater than when the same cans are cooled in water having no more than 100 organisms per cubic centimeter. The importance of maintaining low levels of microbial population in cooling water is obvious.

Factors of design and operation of cooling equipment often contribute toward increases of microbial levels during operation. Where cooling is carried out in still retorts and where the cooling water is not reused, there is no danger of microbial build-up, and total counts are low unless the original water source bears contamination. Cooling canals are susceptible to microbial build-up during operating periods unless chlorination is employed or adequate fresh water is supplied continuously, and the canal is constructed and piped to insure a water circulation through all parts and to avoid dead ends where water may stagnate. Continuous rotary cooler waters have been found to be very susceptible to relatively rapid increases in microbial content during operation. Spray cooling systems or any other type of cooling equipment where cooling water is recirculated are likewise susceptible to the bacterial build-up during operation. It is important in any type of cooler to prevent an accumulation of organic material washed from the outsides of cans into the cooling water. Such material provides nutrients for the growth of microorganisms and thereby promotes rapid bacterial build-up. It also absorbs free chlorine, and interferes with the maintenance of proper chlorine levels where chlorination is practiced.

Spoilage of processed canned products by the admission through sound cans of micro-organisms borne by cooling water is aggravated by rough handling of the wet cans immediately after cooling. Denting of double seams in automatic filled can handling equipment increases the rate of spoilage anticipated in any lot of cans. Rough handling in combination with excessive content of micro-organisms in the cooling water usually results in serious spoilage losses.

The microbial level of cooling waters may be controlled by chlorination. Treatment of cooling water by the application of chlorine is fast becoming common cannery practice. The maintenance in cooling water of free chlorine levels between two and four parts per million is ordinarily adequate to keep total bacteria count within safe limits. Chlorine is usually applied to cooling water in the form of solutions of hypochlorites, either by simple drip addition, or through proportioning pumps.

CANNING WATER REQUIREMENTS

The importance of adequate water volume for canning purposes has been emphasized. The water demand of a cannery depends largely upon its production volume and the water requirements of the individual products being packed. However, water requirements are influenced greatly by methods of handling and types of equipment employed, and so are found to vary widely for the same products in different plants. Furthermore, alterations in plant layout, variations in equipment and methods, and changes in cannery technique usually alter the water volume required for the products canned. These facts account for the wide variation in rates of water usage reported for standard canned fruit and vegetable products in various plants.

The table "Canning Water Demand" presents data for a relatively small number of largely typical fruit and vegetable products. Water use data, in gallons per case, are tabulated to show the range of the consumption figures reported, and reflect the differences in plant practice existing between canneries. Principal factors causing wide divergence in water requirement for similar products are the degree to which water is used for fluming, the methods of cooling employed, and the extent to which water recovery and re-use are practiced. The limited data presented here indicate the possibility for further development in methods of conserving canning water, and the need for the education of cannery engineers and operators in such methods.

WATER ANALYSIS

A typical water analysis form is shown on the following Page.

Various water tests and their significance are outlined below.

1. *Alkalinity*

Carbonate alkalinity is measured by titrating with 0.02N sulfuric acid using phenophthalein as the indicator. Bicarbonate alkalinity is titrated with 0.02N sulfuric acid using methylorange as the indicator. The combination of the two indicates the total alkalinity. High total alkalinity will cause rinsing problems. Samples testing over 200 ppm alkalinity often require acid rinsing to prevent water spotting and a general dull appearance on equipment sufaces.

2. *Hardness*

(a) Temporary hardness is attributed to calcium and magnesium *bicarbonates* which decompose upon heating into insoluble carbonates or scale. A good example is tea kettle scale. Alkalinity over 100 ppm will quickly form films in heating equipment.

(b) Permanent hardness represents soluble calcium and magnesium salts which are not decomposed by heat, but are precipitated with certain dilute alkalies.

An example is the scale in the alkali removal section of a bottlewasher. Tests show that over 150 ppm alkalinity usually causes rinsing problems and excessive chain lubrication costs.

WATER ANALYSIS

ACCOUNT DATE

LOCATION REF. NO.

DISTRICT SALESMAN

SAMPLE SOURCE TAP WATER

	tost		ppm	as
1.	ALKALINITY	CARBONATE	30	$CaCO_3$
		BICARBONATE	170	$CaCO_3$
		TOTAL	200	$CaCO_3$
2.	HARDNESS	CARBONATE (TEMPORARY)	30	$CaCO_3$
		NON-CARBONATE (PERMANENT)	0	$CaCO_3$
		TOTAL	30	$CaCO_3$
3.	CHLORIDES		26	NaCl
4.	IRON		Neg.	Fe
5.	SULFATE		200	SO_4
6.	SULFIDE		Neg.	S
7.	APPEARANCE	Clear and colorless		
8.	pH	8.8		

PARTS PER MILLION (ppm) + 17.1 = GRAINS PER U.S. GALLON (gpg)

ANALYST APPROVED BY

3. *Chlorides*

High chloride content causes rapid corrosion, increases soap consumption and reduces suds and foam. Tests showing over 100 ppm chlorides may indicate the need for a demineralizer or corrective maintenance of the water softener.

4. *Iron*

As little as .3 ppm iron can be expected to cause staining on equipment surfaces because iron precipitates with the addition of some alkalies or oxidizers such as chlorine. Additional complex phosphates may be required to prevent this problem.

5. *Sulfate*

A positive sulfate test indicates sediment or turbidity problems which may require filtration.

6. *Sulfide*

The presence of sulfides is directly associated to a sulfurlike odor which is objectionable in food plants.

7. *Appearance*

Appearance refers to sediment, color and clarity of the sample.

8. *pH*

The pH of water can generally be related to the mineral composition. Where carbonates and bicarbonates predominate, pH values are usually above 7.0. Sulfides and sulfates cause pH values below 7.0.

The pH measurement is made with a pH meter. Low pH (below 7.0) increases the corrosion rate. High pH often indicates the need for an acidified rinse.

There are many additional water tests which can be considered, but food plants will no doubt find microbiological analysis necessary to maintain superior quality.

A complete water analysis is important because it can serve as an excellent guide for the plant operator to:

(a) Select the proper cleaning materials and procedures
(b) Get better heat transfer from heating and cooling equipment
(c) Reduce lubrication costs on conveyors
(d) Prevent unsightly films on processing equipment
(e) Control bacteria counts where water is in direct contact with foods

CHEMICALS IN WATER

Water used in canning vegetables and fruits must be soft and free from any appreciable amount of organic material, obnoxious odor or taste. The presence of sulfur or a salty taste, for instance, will affect the finished product and may cause discoloration or hardening as well as objectionable odors. If the water is too alkaline, the product may become disintegrated or mushy; if the water is too hard, it will harden vegetables, often making them difficult to process. Even the water used for cooling cans should be reasonably low in bacterial content. However, the water used in cooling, in scrubbing floors, and in sprinkling does not necessarily have to comply with the same standards as that used in the preparation of the canned product.

Hard water is objectionable for the boiler supply, for the brine, for syrups and for all canning purposes. The hardness of water is due to the presence of calcium (lime) and magnesium compounds. These compounds have the effect of hardening certain vegetables, especially peas and beans.

The zeolite method is one which has been used satisfactorily for softening water for canned foods. In this method, the water is passed through a tank or cylinder filled with a granular substance belonging to the class of compounds known as zeolites. This substance has the property of taking up calcium and magnesium from water passing through it, and yielding up to the water an equivalent amount of sodium. When the zeolite is no longer sufficiently active, it can be regenerated by passing a strong salt-brine through it. This brine removes from the zeolite the calcium and magnesium taken up from the water and leaves in

CANNING WATER DEMAND

Product	Can Size	Gallons of Water Per Case
Asparagus	No. 2, 2 Tall, 300	65–190
Green & Wax Beans	No. 2	45– 55
Beets	No. 2	40– 50
Carrots	No. 2	40– 55
Corn, Cream Style	No. 2	40– 50
Corn, Cream Style and Whole Kernel	12 oz., 303, No. 2	25– 82
Whole Kernel Corn with Peppers	12 oz.	50– 82
Lima Beans	No. 2	40– 55
Mixed Vegetables	No. 2	50– 60
Peas	303, No. 2, No. 2T	31–135
Pumpkin	No. 2½	60–165
Spinach and Greens	No. 2, 2½	75–260
Tomatoes	No. 2½	50– 66
Apples	No. 10	75–150
Apricots	No. 2½	50–150
Cherries, Sweet	No. 2½	90–180
Peaches	No. 2½	30–320
Pears	No. 2½	25–180
Plums	No. 2½	50–150
Misc. Fruits	No. 2½	50–100
Misc. Fruits & Vegetables		60
Baked Beans	28 oz.	85
	14 oz.	43
Hominy	No. 10, 2½, 2	55– 70
Brown Bread		58
Beans, Soaked Dry	No. 2, 2½	30–123

their place an equivalent amount of sodium. In this way, the tank or cylinder apparatus can be used for softening water during the daytime and can be regenerated with salt at night to be ready for the next day's operations.

All commercial salt contains calcium and magnesium compounds in some quantities, depending on the source of the salt and the degree of its purification. Therefore, it may happen that the salt used will contribute more to the hardness of a brine than the water supply. In this case, it is advantageous to use as pure a grade of salt as possible for brining products. Canners should use a salt for this purpose which contains less than 0.3 percent of calcium (equivalent to 0.75 percent of calcium carbonate). It is also advisable to use as weak a brine as is possible without materially sacrificing flavor, in order to minimize the hardening effect of calcium and magnesium.

The table "What a Water Test Report Means" is helpful for interpreting the results of chemical analysis of water.

WHAT A WATER TEST REPORT MEANS

Item	Recommended	Problems from excessive amts.
Acidity	pH 7.2–7.5	Below pH 7.0 causes corrosion of copper and iron pipes. See Copper.
Sediment Odor Color	Nothing permitted contributing to bad taste, odors, or appearance	
Sodium	No specified limit	Has possible health effects in persons with heart, kidney, or circulatory ailments.
Potassium	Less than 20 p.p.m.	Contributes to growth of small organisms in water (Plankton).
Iron	For drinking – 0.3 p.p.m. or less	Causes poor-flavored water, brown stains on plumbing and laundry. See Acidity.
	For dairy use – not over 0.1 p.p.m.	Contributes to oxidized flavors of milk.
Manganese	Maximum 0.05 p.p.m.	Is possible health hazard. Causes poor tasting coffee and tea, "brown laundry", brown stains on fixtures.
Copper	For drinking – 1.0 p.p.m. or less.	Is health hazard. Causes poor-flavored water, blue or green stains on fixtures or laundry. See Acidity.

WHAT A WATER TEST REPORT MEANS – Continued

Item	Recommended	Problems from excessive amts.
	For dairy use – not over 0.1 p.p.m.	Contributes to oxidized flavors of milk.
Lead	0.05 p.p.m. or less	Causes serious illness or death. See Acidity.
Fluoride	0.7 to 1.2 p.p.m.; recommended limit 1.7 p.p.m.; grounds for rejection 2.2 p.p.m.	Large amount may cause mottling of teeth.
Turbidity	0 to 5 units	Increases in turbidity after rainfall may indicate surface or other introduced pollution.
Hardness as $CaCO_3$	Less than 100 p.p.m. (Hardness is commonly measured in p.p.m. or grains per gallon – g.p.g. One g.p.g. = 17.1 p.p.m.)	Increases detergent and soap needs, causes scale on pipes and heaters. Soap curd shortens life of cloth fibres.
Calcium as $CaCO_3$ Magnesium		The two elements, calcium and magnesium, compose the majority of hardness.
Sulfate	250 p.p.m. or less	May cause laxative effects.
Phosphate	No Standard	May stimulate the growth of algae.
Ammonia nitrogen Albuminoid nitrogen Nitrite nitrogen Nitrate nitrogen	0.01 p.p.m. or less 0.05 p.p.m. or less 0 0.5 p.p.m. or less	If two or more of these four items exceed the specified limits, sewage contamination is suspected.
Chloride	Most waters have less than 10 p.p.m.	If chloride content is normally low an increase may indicate sewage contamination.
Residual chlorine	Palatable waters will not contain enough chlorine to harm man or livestock	
Total dissolved solids	500 p.p.m. or less	Excessive amounts may be associated with poor-flavored water and health hazards.

WATER QUALITY IN VEGETABLE CANNING

In the washing of peas preliminary to the process of canning, or in the rinsing of peas by means of a spray after blanching, the hardness of the water has no appreciable effect on the hardness of the canned product. But in the blanching of peas, hard water does have a pronounced hardening effect on the canned product.

When blanching is done in a wire basket or perforated pail suspended in a tank of hard water, the canned product is bound to be affected. However, when this operation is done in the continuous blancher, as usually employed by large canneries, it is found that the peas first passing through the blancher remove the greater part of the calcium and magnesium compounds from the blanch water and thus soften it. Nevertheless, if very hard water is employed and the flow of the water through the blancher is considerable, the hardening effect on the peas will be greater and proportional to the flow of water. It may be stated then that the use of softened water for blanching is advantageous when the hardness of the water supply exceeds 200 parts per million (expressed as total calcium).

The hardening effect of calcium and magnesium compounds on dry beans is even greater than that on peas. Therefore in packing dry beans, it may be advantageous to soften water that is only slightly hard. Softening of hard water also for soaking dry beans and, of course, for the preparation of brine and sauce, is therefore important. If the soaking water is changed during the soaking period, such treatment is all the more important.

The hardness given dry beans by the calcium and magnesium compounds of hard water or salt may be partially corrected by long processing. But the appearance of a product so treated is sometimes less satisfactory than that of beans treated with soft water and relatively pure salt and given merely the processing necessary for sterilization. Therefore, the use of soft water and pure salt gives a superior product, resulting in the saving of time and in the amount of steam consumed in processing.

Calcium and magnesium compounds in hard water and salt do not appear to exert a hardening influence on string beans. The softening of water for use on this product does not, therefore, appear to be of any great value.

Calcium and magnesium compounds in hard water and salt do not exert a hardening influence on either cream style or whole grain canned corn. The use of softened water in the brine of cream style canned corn appears to produce a somewhat darker product than the unsoftened water. Its use therefore is regarded as disadvantageous.

Calcium and magnesium compounds in hard water and salt will combine with the soluble oxalates naturally occurring in beets, and may produce a white coating on their surface. This is especially apparent on cut beets and sometimes detracts from their commercial value. The softening of hard water and the use of relatively pure salt are therefore advantageous in avoiding this trouble.

WASHING OF FRUITS AND VEGETABLES

In canning fruit, the volume of water required varies with the method of preparation of the fruit for canning and with the kind of fruit. Lye-peeled peaches and tomatoes require much more water than plums or cherries, since very large quantities of water are needed for washing. In one typical large California cannery the amount of water used each day ranges from 80,000 to 90,000 gallons for each 75 to 100 tons of fruit or tomatoes.

The rotary washer used in the lye peeling of peaches is very effective. It consists of a rotary drum or series of several drums, each of which is equipped with an inner helical conveyor. These drums rotate in tanks of water in which the water is continuously or frequently changed. The spiral carries the fruit progressively through the different washing tanks, the first of which is contaminated with a small amount of lye from the lye peeling tank; the last two tanks are filled with hot and cold water respectively.

The effectiveness of the rotary washer depends on the speed with which the product passes through the washer, the volume of water used, the temperature of the water, the distance of the sprays from the product, and the depth of the product in the washer. Many washers are overloaded when processing such products as tomatoes, with the result that much of the material does not receive the full force of the sprays. In many tomato product plants a combination of roller, conveyor and sprays is used. The conveyor is about 2.5 feet wide and is made of bronze or stainless steel tubes about 3 inches in diameter, placed crosswise and moved by an endless link chain. As the conveyor travels, the tubes revolve, turning the tomatoes over and over and exposing them on all sides to the sprays. Two sets of sprays are used–one under very heavy pressure and the other under medium pressure. Beyond the sprays the roller conveyor serves as a very effective sorting belt.

If the fruits or vegetables are agitated in water, the efficiency of the soaking process is greatly enhanced. A simple form of agitating device, often found in cider factories for the washing of apples, consists of a wooden flume in which the apples are conveyed through a current of rapidly running water. Compressed air may also be used to agitate the water in tanks in which the fruits or vegetables are to be washed. In one method of washing spinach, the water in the tank is agitated by means of a pump. Some soaking vats are equipped with a propeller which may be in contact with the product; in this case, the propeller should move slowly to avoid bruising.

Washing of fruits and vegetables by means of sprays of water is the most satisfactory method. A product that is heavily contaminated with soil should be thoroughly soaked to loosen the soil before passing it under sprays. The efficiency of a spray of water for washing depends on the pressure of the water, on its volume, and also on the distance of the spray nozzle from the product to be washed. The spray in which a small volume of water under heavy pressure is used is much more effective than the one in which a large volume of water under low pressure is employed.

Most spray washers consist of pipes that are fitted with hack-sawed openings, but for pressures of water in excess of 20 pounds per square inch, adjustable nozzles should be used to prevent unevenness and to direct sprays in the desired channels. Sprays are effective only if the water touches all parts of the surface of the product. One means of attaining this objective is to place sprays above and below the traveling woven-wire-cloth conveyor. The same effect also can be attained by causing the product to roll over the spraying process. The most effective means of agitating the product under the spray is a revolving spray washing machine used on tomatoes and roots. This consists of a slightly inclined perforated drum, fitted on the inside with spirals or with corrugations. This type of washer is also effectively used in the washing of spinach.

WATER USE AND CONSERVATION

The first question to be asked on water usage in processing plants should be: Are you using enough water? The primary consideration in the use of water is to accomplish the task for which the water is being used. In addition to product conveyance, such as in flumes, two of the more important uses are in washing the raw product and cooling of the finished product. These primary purposes must be accomplished without any sacrifices as to the amount of water being used. There are a few trends in the food industry that suggest an increase in water usage, as follows:

1. Research has shown that microbial counts for foods in the final container as it relates to spoilage probabilities, is influenced by the sanitation condition of the plant and the quality of water in which the product has been handled and conveyed. Due to increased emphasis on quality and more rigid definitions of clean food, it has been estimated that approximately twice as much water is now used per case than 20 years ago. The increased interest shown by regulatory agencies and Government buying agencies on the sanitation of the plant and the wholesomeness of the final product suggests even a further increase in the amount of water used per case of product.

2. In this era of mechanical harvesting even a further increase in water may become necessary for field cooling, water hauling, and removal of excess soil and debris which appears to be characteristic of mechanical harvesting as compared to manual harvesting.

3. Increased use of water conveyance systems results also in greatly increased water usage.

Regardless if enough water is being used or not, or if more water will be required to accomplish certain tasks in the future, there is always room for water conservation in most plants due to:

a) New processing procedures; b) More efficient equipment; c) avoiding unnecessary use or waste of water; and d) reuse or recirculation of water.

It must be remembered that all water released in the plant regardless of how small the amount has to be disposed of in some manner or another, resulting in an additional load on the waste disposal system. In addition each of us has a responsibility to conserve the quantity and preserve the quality of the waters of our state and nation. Thus, the second question to be asked is: How can the total load (water) on the waste disposal system be reduced?

A recent survey conducted by NCA showed several interesting facts, such as:

1. As the operating rate increases the use of water per unit product decreases. Thus any factors which increase the flow of product through the plant are a step in

the direction of more efficient use of water. Along this same trend, factors which improve case yield/per ton of product decrease the waste load per unit of raw product being processed.

2. New and improved equipment is having a tremendous impact on water utilization. Continuous cookers and hydrostatic sterilizers have resulted in significant decreases in water used per unit of product in contrast to still retorting. Improved and more efficient fillers which have less spillage will conserve water and also reduce the BOD load of the waste.

In general it appears that some of the more advanced and automated equipment coupled with better methods of handling water and waste, such as better spray washing systems, improved cooling systems, automatic-monitoring and control of water flows, separation of concentrated from dilute waste, improved clean-up operations, and recirculation of water can contribute significantly to the efficient utilization of water.

Unnecessary Use or Waste of Water

The following suggests certain areas where the processor should pay particular attention in relation with unnecessary use or waste of water:

1. All water hoses should have automatic shut-off valves to prevent waste of water when hoses are not in use. A running hose can discharge up to 300-400 gallons of water per hour.
2. Use low-volume, high-pressure nozzles rather than low-pressure sprays for clean-up. The high-pressure system uses less water and does a more efficient job of cleaning.
3. Avoid unnecessary water overflow from equipment, especially when not in use.
4. Avoid using water to flume the product or solid waste when the material can be moved just as effectively in a dry-state by conveyors.
5. Avoid using water in excess of the amount needed to accomplish the job, such as reducing cooling water flow to the minimum needed to accomplish the necessary temperature drop.
6. Rain water run-off from buildings should be diverted away from the factory and not allowed to inadvertently be collected in the waste disposal system.
7. Certain water used in the plant, especially can-cooling water, which is not reused and which meets the purity requirements of applicable state and federal regulations may be discharged directly into streams without prior treatment through a waste disposal system. In some cases this may amount to over 50 percent of the total water used.

Reuse of Water

The indiscriminate reuse of water in the processing plant can result in costly spoilage losses. However, reuse of water under recommended practices can greatly reduce total water consumption. In general, the reuse of water in certain operations is permissible if certain water quality factors are met and certain guidelines followed:

Where only fresh water should be used. All prepared or partially prepared products, such as blanched peas, beans, asparagus, dried fruit, peeled tomatoes, etc., should only come in contact with fresh water. Also, only fresh water should be used in blanchers or in final flumes and product washers. (Also see Water-Economy Check Table).

Where reuse of water is permissible. By using the counterflow principle of water usage; i.e. the cleanest or final water may be reused within a given operation, such as in a sequence of washers or flumes, if it is counter-flowed to the direction of movement of the product. For example, where a raw, unprepared product is given two successive cold-water immersion washings, the water from the second washing may be used as make-up water for the first washing, if it is not heavily contaminated with organic matter and insects. The same principle would apply to flumes used for conveying and washing raw unprepared produce.

The water from can coolers, in general, is fairly uncontaminated and may be reused as make-up water in can cooling as well as at numerous other locations within the plant. (See Water-Economy Check Table).

Precautions in the reuse of water.

1. Recirculation of washer and flume water (using the counter-flow system) must be carefully controlled to prevent excessive accumulation of soil and organic debris.

2. Reclaimed water for washers and flumes should be effectively chlorinated if the temperature is not held at 80°F or below.

3. All water for reuse should first be screened. If used for cooling cans, it must be chlorinated, and chlorination is recommended for all reused water. (A chlorine residue of 0.5 to 1 ppm increased to 4-5 ppm for a short time about every two weeks).

4. Water must not be reused for any purpose other than cooling cans if it has been treated with dichromate or other corrosion inhibitors.

5. If cooling water is reused in equipment other than can coolers, a separate piping and pumping system is required, with no cross connections to the potable water supply.

The following "Water Economy Check Table", will be useful as a guide on the reuse of water:

WATER ECONOMY CHECK TABLE

Operation or Equipment	May Recovered Water be Used?	May Water From This Equipment Be Reused Elsewhere in Plant?	Source of Water for Reuse in Equipment
1. Acid dip for fruit	Yes	No	Can coolers
2. Washing of product			
A. First wash followed by 2nd. wash	Yes	No*	Can coolers
B. Second or final wash of product	No	No*	
3. Pump Elevators (peas, etc.)			
A. Raw product suspended in water	Yes	No*	Can coolers
B. Pumping of partially prepared product suspended in water	No	No*	
4. Flumes			
A. Fluming of unwashed or unprepared product (peas, pumpkin, etc.)	Yes	No*	Can coolers
B. Fluming prepared or partially prepared product	No	No	
C. Fluming of wastes	Yes	No	Any waste water
5. Lye peeling	Yes	No	Can coolers
6. Product-holding vats; product covered with water or brine	No	No	
7. Blanchers – all types			
A. Original filling water	No	No	
B. Replacement or make-up water	No	No	
8. Salt brine quality graders followed by a fresh water wash	No	Reused in this equipment	
9. Washing pans, trays, etc.			
A. Tank washers–original water	No	No	
B. Spray or make-up water	No	No	
10. Lubrication of product in machines such as pear peelers, fruit size graders, etc.	No	No	Can coolers
11. Vacuum concentrators	Yes	Reused in this equipment after cooling and chlorination	
12. Washing empty cans	No	No	
13. Washing cans after closing	Yes	No	Can coolers
14. Brine and syrup	No		
15. Processing jars under water	Yes	Reused for processing	Can coolers, and processing or cooling water from other retorts used for processing glass

*A certain amount of this water may be reused for make-up water in this equipment if the counterflow principle is used with the recommended precautions.

WATER ECONOMY CHECK TABLE – Continued

Operation or Equipment	May Recovered Water be Used?	May Water From This Equipment Be Reused Elsewhere in Plant?	Source of Water for Reuse in Equipment
16. Can coolers		Water from these coolers may be reused satisfactorily for cooling cans after circulating over cooling towers, if careful attention is paid to proper control of replacement water, and to keeping down bacterial count by chlorination and frequent cleaning. This water may be reused in other places as indicated.	
A. Cooling canals			
1. Original water	No		
2. Make-up water	Yes		
B. Continuous coolers where cans are partially immersed in water			
1. Original water	No		
2. Make-up water	Yes		
C. Spray coolers with cans not immersed in water	Yes		
D. Batch cooling in retorts	Yes		
17. Clean-up purposes			
A. Preliminary wash	Yes	No	Can coolers
B. Final wash	No	No	
18. Box-washers	Yes	No	Can coolers

PROTECTING THE WATER SUPPLY

An important sanitary precaution often overlooked in food plants is the possible contamination of a potable water supply by polluted water where it is either injected directly into the potable water line, mixed with steam, or anywhere there is a submerged potable water inlet.

Water entry into CIP tanks, case washers, parts washers, etc., requires preventive measures to stop contaminating back flow into the main water supply. The use of injectors to feed sanitizers or the use of proportioning pumps to feed lubricants also require similar preventive measures.

Most city codes require that equipment and fixtures connected to a potable water supply, where the water supply enters below the flood rim, be protected against back-siphonage of polluted water by an air gap, atmospheric vacuum breaker or other approved method.

An air gap is the physical separation of the potable and non-potable systems by an air space. The distance between the supply pipe and the flood lever rim should be two times the diameter of the supply pipe, but never less than one inch.

Atmospheric vacuum breakers may be used only when connected to a non-potable system where the vacuum breaker is never subjected to back pressure and is installed on the discharge side of the last control valve. They cannot be used under constant pressure and must be installed with the bottom of the breaker body at least 6 inches above the flood rim of the fixture or appliance. Where a portable appliance is used, the breaker should be installed at least 6 inches above the highest point the outlet can be raised.

Pressure type vacuum breakers may be used where the vacuum breaker is not subjected to back pressure. They may also be used under continuous supply pressure. They must be installed at least 6 inches above the usage point.

Back-flow preventers with atmospheric vent may be used as an alternate for pressure-type vacuum breakers and to provide protection against back pressure.

A potable water supply should never be solidly piped to a drainage ditch, sewer or sump and should be terminated twelve inches above the ground or through an air gap to a drain.

The plant's water supply should be protected. Improper plumbing usually contaminates the plant's water first and then the neighbor's. Safety should be a prime consideration. The local plumbing code should be followed.

SALT (SODIUM CHLORIDE) AND BRINES

Information on salt, brines, and brine preparation is presented in Chapter 3, "Canning of Vegetables," on pages 340 to 342.

SWEETENERS

An understanding of the total sweetener picture is extremely important to the modern canner. He must take advantage of the specific characteristics of each sweetener to gain the most quality advantages for his products within the applicable standards and the economics involved.

Sucrose is only one of many sugars and its use as the sole sweetening ingredient is not the common practice. The subject of sweeteners for canned foods should be examined from the broad and complex viewpoint of total sweetener applications. Sweetener functions, economics, availability of various sweeteners, world markets, distribution advantages, the needs of the canner to achieve various desired characteristics, and federal and state regulations all play a part in the total sweetener canning application. The total sweetener concept is heightened by the common practice of blending these various sweeteners for shipment and distribution throughout the country in accordance with the canners needs and within the standards as specified by law for specific packs. The major canned foods using sweeteners either alone or in blend may be noted in Table 1.

Table 1. Canned foods that usually contain sweeteners.

FRUITS	VEGETABLES	CONDIMENTS
FRUIT JUICES	(PORK AND BEANS)	(SALAD DRESSINGS)
TOMATO PRODUCTS	(HARVARD BEETS)	(MAYONNAISE)
(CATSUP)	(SWEET POTATOES)	MEAT PRODUCTS
(CHILI SAUCE)	PICKLES–RELISHES	(CHILI)
(TOMATO SAUCE)	CANNED PUDDINGS	(STEWS)
(TOMATOES)	JAMS, JELLIES, PRESERVES	(SAUSAGES)
	TABLE SYRUPS	SOUPS
	PEANUT BUTTER	

The approach to the viewpoint of total sweetener application for the canning industry must start with the requirements of the consumer, the needs of the canner to meet these requirements, and the functions expected of the sweetener or sweetener blend. Sweetener functions may be noted in Table 2.

Table 2. Sweetener functions.

NUTRITION	COLOR	BODY	CRYSTALIZATION
SWEETNESS	SHEEN	SURFACE TENSION	COHESIVENESS
FLAVOR CONTROL	ANTI-OXIDATION	OSMOTIC PRESSURE	TEXTURE
	VISCOSITY	ANTI-FERMENTATION	

No single sweetener could be expected to provide all the characteristics shown in Table 2 to the complete fulfillment of each characteristic. Practically any canned food requires more than one and usually several of these characteristics. Each sweetener type treated here has its specific advantageous characteristics which offer the canner an opportunity of choice for best results. Following is a discussion of the major sweeteners used in canned foods.

Sucrose

Sucrose or common table sugar is a disaccharide and may be considered as a molecule of dextrose bound to a molecule of levulose. Sucrose is obtained commercially from both sugar beets and sugar cane. It is the most commonly used sweetener and is applied in almost all of the canning processes which employ sweeteners of any kind.

The primary function of sucrose is its sweetness and its contribution to flavor. In addition, sucrose as all the sugars contributes nutrition, some sheen, viscosity, body, and to a minor extent, anti-oxidation. Being the original and most common of all the modern commercially available sweeteners, it has been based at 100% sweetness. Because it is a disaccharide, the body, surface tension characteristics, and mouthfeel are limited at any given concentration of sweetener. The anti-oxidation characteristics arise basically from the fact that in most applications, the sugar is boiled in solution which salts out dissolved air. An example of this is the syrup boiled prior to filling and added as cover syrup in fruit canning. Sucrose has no aldehyde or ketone reducing groups to perform reduction in favor of reducing materials in the primary food being canned. Sucrose is the one sweetener allowed in all foods which permit addition of sweetener, again primarily due to its historical acceptance. Other sweeteners are permitted and continue to be permitted through petition and revision of standards.

Although supplying a major portion of the requirements for a sweetener, sucrose may not achieve a given functional requirement to its fullest extent. Thus blends of various other sweeteners with sucrose are available in the U. S. Sucrose is available nationwide in bags or dry bulk and in most locations straight or in blends in tank cars or tank trucks as liquid sugar.

Invert Sugars

Invert sugars are used extensively in the canning industry particularly in fruit, fruit juices, and condiment types of foods depending on the need for its characteristics, availability, and the economics involved. Invert is simply the name for the mixture of dextrose (glucose) and levulose (fructose) in approximately equal combination when these two sugars are chemically split from sucrose. Since sucrose is rarely inverted 100%, the commercial inverts available are mixtures of levulose, dextrose, and sucrose.

Various invert sugars are available, such as industrial invert at about 55% actual dry basis invert. These inverts are sold commercially in liquid forms and vary in dry substance from about 70% to 77% dry solids.

Invert sugar has been rated at approximately 135% sweetness based on sucrose at 100%, whereas levulose has been rated upwards to 166-175% sweetness depending on grade and type of application.

Invert sugars are used mostly in fruit, fruit juice, and condiment canning. Generally, invert sugars are not used in products at neutral pH or in products containing protein due to the presence of the aldehyde group in the dextrose molecule and the ketone group in the levulose molecule. These aldehyde and ketone groups both combine with protein in what is called the Maillard or browning reaction which results in darkening of the food. In some canned foods, coloring is desirable. Examples of such exceptions are pork and beans and sweet potatoes. The browning reaction is dependent on the type and amount of protein, the amount of dextrose or levulose and, of course, the amount of heat and extent of time the heat is applied.

Functionally, invert is used for its sweetness and at times for its economics over sucrose for this function. In addition, invert provides some sheen and mouthfeel although, being simple sugars, not to the extent provided by sucrose. Invert, again because it is composed of simple sugars, does provide a higher osmotic pressure than does sucrose and consequently permeates fruit or vegetable membranes faster than sucrose. This causes less shrinkage in processing than does sucrose. Invert sugars with reducing radicals are to a certain extent more of an anti-oxidant than straight sucrose.

Invert sugars are not used in jams, jellies, and preserves because they are sold in liquid form which means extra evaporation time and also because of crystalization danger. At room temperatures dextrose is about 49% soluble which in a 68% solids jelly it means that not more than 31% dextrose can be tolerated. At refrigerator temperatures, far less dextrose can be tolerated without crystalizing. With corn syrup usage at 25% of the sweetener addition, crystalization can be controlled to a reasonable extent but since sucrose forms its own invert in time, little invert sugar is used as the original sweetener adjunct.

The levulose in invert, although advantageous from a pure sweetening standpoint, also has an additional color disadvantage over just the browning reaction. In acid media and particularly at low pH conditions, such as in jams and jellies, levulose has a tendency to form saccharinic acids which are very dark in color and also produce an off-flavor.

As in the distribution of sucrose, invert sugars are available in blends with dextrose and various corn syrup types through the many refineries located over the U. S.

Sweeteners from Corn

To understand corn-derived sweeteners, one must understand corn starch and corn conversion. Corn starch is made up of long chains of glucose units linked together. These chains may be straight chain linkages called amylose or the chains may be branched called amylopectin. With sufficient heat, pressure, and acid these chains are easily broken at the oxygen linkages into smaller molecules. That reaction is called hydrolysis. If the hydrolysis is only slight, the product is a thin boiling starch. If the hydrolysis is continued dextrins are formed, then maltrins or hydrolyzed cereal solids, then the range of varying corn syrups, and finally if the conversion is carried to its conclusion the end result is dextrose. Similar conversions or hydrolysis can be accomplished with various enzymes. With proper enzymes high maltose or even levulose syrups can be manufactured.

Dextrose

Dextrose is a monosaccharide and occurs naturally in virtually all plant materials and, also, in digestion and metabolism in animal systems from starch, and even from protein. It is the primary sugar in fruits and has historically been called "fruit sugar". Dextrose commercially is available in either the hydrate or the anhydrous form. The hydrate form of dextrose is the most stable form and contains one molecule of water bound in the crystaline structure to one molecule of dextrose. This is bound water and not free water. When anhydrous dextrose is exposed to the atmosphere it eventually converts to the hydrate form.

Commercial dextrose is manufactured almost entirely from corn starch. Dextrose is used extensively in all types of fruit and vegetable canning where standards permit sweeteners.

Dextrose is used extensively in fruit canning such as berries, peaches, pineapple, and citrus generally as a one third blend with sucrose or invert sugar. In vegetable canning, dextrose is used with sucrose in pork and beans as a coloring agent since it reacts with protein to provide beans with a suitable color. Dextrose is also used in canned corn, beets, and in sweet potatoes again with sucrose to provide a suitable color.

Dextrose is used to some extent in jams, jellies, and preserves at about 10% to 20% replacement of sucrose and generally in formulas with regular or high maltrose corn syrups and with the corn syrup at 25% of the total added sweetener. Present regulations limit corn syrup content in jams, jellies and preserves to 25% of total sweetener, but technologically and quality wise it is possible to increase ratio of corn syrup to sucrose to 50-50. Dextrose in the 10%-20% replacement products tends to produce a desirable short texture rather than a long stringy texture. Dextrose is limited to about 20% of the sucrose addition as amounts greater than 20% even with high maltose syrups may cause crystalization of dextrose.

Meat products permitting sweeteners generally allow dextrose within defined limits. Where dextrose limits are not defined, dextrose is not generally used at over 2% of the packed meat product again due to the formation of dextrose proteinates and possible darkening of product.

Dextrose is widely used in tomato products permitting sweeteners and also condiment types of canning as dextrose does not form saccharinic acids or discolors nearly as readily as levulose in high acid media. Dextrose is used in pickle packs and finds advantage in a faster penetration with increased yield over sucrose or corn syrup.

The functionality of dextrose lies particularly in its being a simple sugar with greater penetration due to its high osmotic pressure as compared to sucrose or corn syrup solids. It also is used as a sweetener, as a sweetener and flavor control, and for its providing of short texture as noted in jams and jellies. Dextrose has long been known for low viscosity where desired. With an aldehyde group in the molecule, dextrose does have added reducing power over sucrose and corn syrups.

Being a simple sugar, it does not produce as much sheen as the corn syrups. It has limited solubility at ambient temperatures alone but excellent solubility in blend with sucrose. Sucrose for example has a solubility of 67% at 74°F, whereas a blend of 32% dextrose and 68% sucrose has a solubility of 75% at 74°F which is an advantage of both against fermentation and in transporting higher solids.

Dextrose has a sweetness rating of 70%-80% compared to the 100% base for sucrose. Sweetness ratings can be misleading as sucrose sweetness is sensed primarily by the anterior taste buds of the tongue, whereas dextrose sweetness is sensed primarily by the posterior taste buds. Thus, with certain fruit flavors, a 20% replacement of sucrose with dextrose is equally as sweet and in some instances seems sweeter than straight sucrose. This is known as the "synergistic effect of sweeteners" and can be noted with all the commercial sugars in combination with each other depending on the type of sugars, the concentration of the sugars, pH, and the product to which the sweetener system is applied.

Dextrose is distributed in dry or liquid form and in blends. Historically, dextrose has been lower in price than sucrose.

Corn Syrup

Corn syrup is a heterogenous mixture of sugars derived from corn starch. It ranges from a dextrose equivalent of 20% to 99%. Dextrose equivalent (D.E.) is an expression of reducing power in Fehling solution as related to pure dextrose. For example, if two parts dry basis of a corn syrup reduce an equal amount of Fehling solution as does one part of dextrose dry basis, the corn syrup D.E. is 50 D.E. When corn starch is converted to corn syrup by acids or enzymes, various sugars of different size molecules are created. Each of these sugars has an aldehyde group and contributes its share to the D.E. As the conversion continues, the molecules become smaller with a trend towards higher maltose and dextrose content, and a consequent higher D.E.

Where permitted by law as is the case with most canned foods, corn syrups are used extensively as a complete sweetener or in blend as a partial replacement of sucrose or dextrose. Such foods include jams, jellies, and preserves; vegetables such as sweet potatoes; fruit, fruit juices, and table syrups; tomato products such as catsup, tomato sauces, and chili; meat products; and condiment food types such as pickles, relishes, and dressings.

Functionally, corn syrup besides being on a dry basis, equal in nutritive value to sucrose, invert sugar, or dextrose, serves as a mild sweetener, anti-oxidant, anti-fermentation agent, viscosity builder, and crystalization controller.

Viscosity of corn syrups decrease as the D.E. increases. The advantages of specific corn syrup types are taken for various specific products. Table syrups are largely composed of regular 43 D.E. corn syrup for reasons of viscosity which provides mouthfeel and also to eliminate the crystalization of sucrose as well as inhibit over-powering sweetness. Corn syrups in the range of 50 D.E. to 70 D.E. are used in sweet potato canning for mouthfeel provided by the combination of high viscosity over sucrose and, also, the extra sheen provided by the larger molecules of the polysaccharides in corn syrup.

Corn syrups in the range of 55 D.E. to 70 D.E. depending on standards are extensively used as a total or partial replacement of sucrose in fruit and fruit juices again providing body, mouthfeel, and sheen.

Corn syrups do not crystalize at standard concentrations of 40°Be-44°Be at D.E. of 65 or less. At 70 D.E. crystalization may take place to some extent and corn syrups above 70 D.E. usually crystalize sufficiently to make shipping and handling difficult unless special heating and storage facilities are applied. Since the standard corn syrups do not crystalize, and further they inhibit crystalization, extemely high concentrations of total sweetener are possible using corn syrups in blend as for example in table syrups in which fermentation is diminished as one approaches 80% solids with as low as 30% replacement of sucrose with corn syrup solids and without crystalization. Standard jam, jelly, and preserve formulas generally employ 25% corn syrup dry basis as a replacement for sucrose which is of great help to the industry since crystalization in virtually unknown since corn syrup was permitted.

Corn syrup also acts as the best binder of all the sweeteners in semi-solid or highly concentrated foods such as some meat products where permitted by standards. The lower the D.E. the greater becomes its binding power.

High maltose and low D.E. corn syrups (25 D.E.-40 D.E.) have low dextrose contents of 5%–12% and are used in products containing milk or other protein for better consistency and color control over other sweeteners. Corn syrups are priced lower than either sucrose or dextrose.

Levulose syrups are included in the corn syrups. Such syrups range in the 40–45 percent levulose range with approximately an equal, or slightly higher, amount of dextrose and are being introduced to the general canning industry. Levulose syrups function very similarly to total invert as obtained from the sucrose process.

SORBITOL AND MANNITOL

Sorbitol and mannitol are carbohydrates which are classified as polyols. That is, they contain more than one hydroxyl group, and have no carbonyl groups. In addition to sorbitol and mannitol, this class includes commonly known glycerine and propylene glycol as well as many other alcohols. Both sorbitol and mannitol occur naturally in fruits such as apples, cherries, and apricots. Commercially available material is produced by the hydrogenation of sugars. Both exist as white, solid, crystals. In addition to the solid state, sorbitol is also sold commercially as a 70% (w/w) aqueous solution.

The Food and Drug Administration allows the use of sorbitol and mannitol in foods in an amount reasonably required to accomplish the intended physical or technical effect. Sorbitol, as a carbohydrate, has a nutritional value of approximately 4 calories/gram. Mannitol, also is a carbohydrate; because of incomplete absorption and metabolism its nutritional value is approximately 2 calories/gram. The relatively slow absorption from the gastrointestinal tract is responsible for the laxative properties of both polyols. The laxative threshold for sorbitol is about 40 grams per day and for mannitol about 10-20 grams/day.

Sorbitol has a relative sweetness of about 55% and mannitol about 50% as compared to sucrose. Both have negative heats of solution which results in a cool sweet taste.

Since sorbitol and mannitol are higher alcohols rather than sugars they are relatively resistant to fermentation and resulting acid formation by microorganisms found in the mouth. For this reason they have been used for sweetening and bodying of "non-cariogenic" foods and soft drinks.

In soft drinks sorbitol solution is typically used at 1-2% to provide body and mouthfeel, enhance flavor, and impart sweetness. Sorbitol may also be effective in masking the characteristic bitter taste of saccharin in beverages containing that sweetener. In wine a small amount of sorbitol (0.5-3.0%) has been shown to chelate low levels of iron and copper and smooth out the bitterness of lower quality wine. The bodying and flavor smoothing make sorbitol useful in prepared cocktail bases and in cocktail foamers. The chelating or sequestering property has also been observed in fruit drinks.

Sorbitol is used to provide body and sweetness in products other than beverages. Sorbitol can be used as a replacement for cane and corn sugars in maple flavored pancake and waffle syrup. It is used at 10-15% of the syrup in combination with a small amount of sodium carboxymethylcellulose. In so-called "dietetic" imitation jellies and jams sorbitol is used in combination with saccharin for sweetness and body. 15% sorbitol in jelly results in a 25° Brix value. Pectin is used to provide the additional necessary thickening. For ease in handling, as well as economy, the sorbitol in these products is added as the 70% solution rather than as a solid.

One of the chief differences between sorbitol and mannitol is in their humectancy. Sorbitol is highly soluble in water and is an excellent humectant. When added as a 70% solution, sorbitol protects the soft, moist texture of shredded coconut. Mannitol is considerably less soluble and is nonhygroscopic. Consequently, it is used as a solid agent to encapsulate flavors used in canned, powdered beverage bases.

The USDA permits the use of up to 2% sorbitol as a replacement for corn syrup solids in cooked sausage labeled frankfurter, furter, wiener, or knockwrust. In these sausages, such as cocktail wieners, the sorbitol improves flavor, facilitates the removal of casings, and helps maintain a desirable color by minimizing caramelization and charring.

CORN STARCH

The food industry requires over 500 million pounds of starch annually and canning represents a major portion of this use. Canners use specially prepared starches whose characteristics depend upon the finished product requirements. Not only must the starch provide the desired product characteristics, such as consistency and clarity, but at times it must withstand high temperature processing conditions, vigorous agitation, and maintain product integrity under adverse storage conditions. Starch should be bland, enhancing the product flavor, and must meet the rigorous microbiological standards of the industry.

In food products, starch is used to provide desirable organoleptic characteristics, improved appearance, and shelf stability. Starch granule form, molecular configuration, and chemical composition vary in nature and can be further changed in manufacture so that the physical properties of starch sols can be controlled to provide the desired results.

Starch occurs in the form of irregularly-shaped particles called granules. These microscopic particles are insoluble in cold water. However, on heating an aqueous suspension of starch, irreversible swelling of the granules takes place. Eventually a temperature is reached at which maximum swelling is observed and the granules rupture, releasing the starch molecules. Significant physical changes take place as the granules imbibe water and swell to several times their original volume during the pasting or cooking process. The behavior of the cooked starch paste is dependent upon the size and shape of the starch molecules. Starch is a high molecular weight polymer having 400 to 2,000 repeating units per molecule (depending upon the botanical source of the starch). The molecules are linear (amylose) or branched (amylopectin) and are found in a ratio of about 1 to 3. Dispersed linear molecules align themselves in parallel fashion and on cooling set to rigid gels. This condition is known as retrogradation or "setback" and is irreversible. The branched chain polymer is less susceptible to molecular association and tends to give a more stable paste.

The repeating units of the polymer are glucose, a simple sugar found in all plants and animals. Starch is completely digestible and is broken down by the normal human digestive processes, providing a caloric contribution of about 4 calories per gram.

The native unmodified starches have the basic characteristics required by the canning industry. However, in many instances finished product requirements make it desirable to modify the basic structure.

Geneticists and plant breeders have provided the starch user with a special variety of corn, waxy maize, which contains starch composed of only the branched molecules (amylopectin). Waxy maize starches have many applications in the food industry. In addition, modified food starches have been developed to change the behavior characteristics of starches so they can meet the critical needs of the food industry in terms of quality, processing, packaging, distribution, and still retain the nutritive quality of the original food.

There are four basic types of treatment used in making modified food starches. These are: bleaching, conversion, crosslinking, and stabilization.

Bleached starches are treated with minimal levels of oxidizing agents which, in addition to lightening the color, help sterilize the starch so it can meet the microbiological requirements of the canning trade.

The next type of starches are those which are treated to reduce the viscosity, permitting the starch to be cooked and used at higher concentrations. Examples of these products are the acid modified or thin-boiling starches and oxidized starches. Crosslinked starches are prepared by a chemical treatment in which the normal binding forces holding the granule together are reinforced by chemical bonds. This modification is used to overcome the tendency of swollen starch granules to break down under extreme processing conditions. The basic idea is to enhance the strength of the swollen granules so they will be more resistant to rupture. Crosslinked starches can be used at much lower concentrations than native starches for thickening foods. Crosslinking also imparts greater tolerance to high acid conditions.

Starches are stabilized by chemically introducing substituent groups onto starch molecules. The purpose of this type of treatment is to stabilize the molecules toward retrogradation and to introduce specific functional properties in some cases. In this way the tendency of corn starch to gel and of waxy starches to lose their hydrating ability and clarity on storage at low temperatures is reduced.

Through the use of these modification techniques starches have been developed which are simple to process, improve product quality and uniformity, and reduce the level of starch use.

The modifications which are permitted in the United States are described in detail in the Food and Drug Administration (FDA) regulations, Title 21, Code of Federal Regulations, Part 121.1031. The use of modified food starches in baby foods was evaluated by a National Academy of Science Committee in 1970 and the use of the products described in the FDA regulations was fully endorsed. In addition, the U. S. Department of Agriculture specifies the use of starch and modified starch in many standarized products.

SPICES, ESSENTIAL OILS AND OLEORESINS, AND SOLUBLE AND DRY EXTRACTIVES

SPICES

The American Spice Trade Association has evolved a broad new marketing definition for Spice: Products of plant origin which are used primarily for the purpose of seasoning food.

Several forms of spices are available to the food manufacturer, ranging from whole and ground natural spices to a variety of extractives, all originating, however, in the natural plant products.

Ground spices are the standard by which flavor quality is measured in seasoning materials. Grinding spices reduce them to a form which is easily added to and dispersed throughout a food. In addition, some of the protective cell structure is broken down and a gradual release of flavor is begun. Thus, ground spices act faster in a food product, flavoring it much more quickly.

Normally, ground spices are processed to allow them to pass through U.S. . Standard sieves ranging from No. 20 to No. 60 mesh. These degrees of fineness do not completely break up the natural cell structure and as a result the ground product will retain an adequate amount of flavor through normal storage, handling and processing. It will also survive re-heating at home, and in some cases, still more spice flavor is released as the consumer chews the food. Different particle sizes of ground spice are recommended for different end uses.

Some processors also grind spices to microscopic fineness, pulverized as fine as 50 microns in diameter. This is done to aid in uniform dispersion, to reduce the possibility of color flecks in the product, and to produce a more complete breakdown of the cell structure.

Low temperature grinding is another relatively recent type of spice processing technique used by some firms. The whole spices are processed through pre-chilled or water-cooled mills, designed to reduce volatilization due to heat generated during processing. Other grinders approach this matter with mills which operate at slower speeds.

Quality in ground spices can depend on many factors: the type of spice; its grade; its country of origin; how it was processed; and where, how and how long it has been stored. Being natural, plant products spices do vary according to type and grade. A modern, well equipped spice grinding firm analyses each lot of raw material it receives and then is able to deliver specified levels of quality in the ground product by its methods of processing. If necessary, lots which test at varying strengths are blended until desired specifications are met. In this way, the grinder can assure his consumer of consistent quality in every shipment. The normal practice for grinders is to retain a sample of every shipment they made so that it can be compared with the next order, and also in case the customer has any questions.

Spice grinders offer microbial control in spices through the use of propylene and ethylene oxides in dry sterilization procedures. Methyl bromide is also used as a fumigant. Spices are first inspected and analyzed for cleanliness at port of entry and must meet the standards of the Food and Drug Administration before they leave the port. Under a program initiated a few years ago, these first analyses are made at importer expense in laboratories recognized by the FDA as qualified for spice analysis.

Lots which do not meet FDA requirements must be reconditioned at the port or returned to the shipper overseas. At this point, all the spices, except paprika, are in the whole form and represent the raw materials of seasoning. Before sale to a food manufacturer or the public, they go next to spice grinding plants where they are further analyzed, cleaned and processed.

ESSENTIAL OILS AND OLEORESINS

These are the most basic extractive. The volatile oils of raw spices are removed by various methods appropriate to the character of the particular spice. Extractive methods include steam distillation, pressing, absorption on a neutral fat, and enzymatic action, followed by steam distillation. Also available are concentrated terpeneless and sesquiterpeneless essential oils which are derived through chromatographic separation or by countercurrent extraction with polar and non-polar solvents. The aim of these latter products is improved stability, since the terpene and sequiterpene components of essential oils tend to oxidize easily when exposed to air or light.

In some spices (notably black pepper) an oleoresin, rather than an essential oil, is the preferred extractive. An oleoresin is a viscous resinous material, the essence of a solvent extraction after the solvent is removed.

While it is possible to use essential oils and oleoresins as is, it is more common in food manufacturing applications to add these materials to some type of carrier. This makes them less concentrated and therefore more manageable. The carrier may be chosen for solubility or some other desirable characteristic.

SOLUBLE EXTRACTIVES

Soluble extractives may be liquid or dry, depending on the carrier. Liquid ones are either water or oil dispersible. Water soluble essential oils and oleoresins are prepared with such solubilizing agents as the polysorbates. Pickle packers and condiment manufacturers use the water soluble flavors.

Extractives are also added to dry carriers, such as salt, or dextrose. The individual crystals are coated with the essential oils or oleoresins. In this case the product is often called a "dry soluble." These are free flowing and easily handled. The carriers dissolve during the processing of the product, leaving the extractives well dispersed.

SPRAY-DRIED EXTRACTIVES

These are another form of seasoning material. Here the essential oils or oleoresins are dispersed in an edible, water soluble gum, often arabic, and then spray dried and blended with a dry carrier. When the water evaporates from the spray particles, the extractives are trapped in a protective coating of the gum. In a sense, the spray drying is designed to reconstruct the protective qualities of the original spice materials, giving the product more stability and longer storage life.

Buying

There is still no substitute for buying top quality in all types of seasoning materials. The rule of thumb in spices is that the prime grades are characterized by higher oil content and therefore are more intensively flavored. They can thus be more economical in the long run because their flavor will go farther in the final products in which they are used. However, in all respects, the first step in spice buying is to make sure to deal with the most reputable firms. This is an area of purchasing where supplier advice can mean a great deal. There is such an array of products and grades, coming from so many constantly changing sources, that it is next to impossible for a food company buyer to keep up with the market.

Storage

Spices should be kept in a cool, dry, well ventilated place. Excessive heat robs them of flavor, and dampness will cake them. Paprika and other capsicums are also sensitive to strong light and therefore the spice storeroom should not be subject to direct sunlight. All spices should be stored on skids and shelves and kept away from contact with outside walls, techniques that avoid dampness. It is good procedure to mark all spice containers with their date of arrival, so that first in is first used. All employees handling them should also be instructed to re-seal the containers immediately after each use, and to make sure they are tight. The drums in which spices are typically shipped today have closures which make re-sealing easy, but they only work if those persons handling them are well trained.

TEXTURED VEGETABLE PROTEINS

Textured vegetable proteins are products which have been transformed from a flour type material into one which has a meat-like texture. The resultant textured vegetable protein product provides chewiness and fibrous character. The USDA defined in 1971 textured vegetable proteins as "food products made from edible protein sources and characterized by having structural integrity and identifiable texture such that each unit will withstand hydration in cooking and other procedures used in preparing the food for consumption."

Soy proteins are the most commonly used base materials for textured vegetable proteins. However, cottonseed, corn, wheat, peanut and similar proteins can be texturized.

Two common methods for texturizing proteins are thermoplastic extrusion and fiber spinning. The extrusion process uses soy flour (50% protein) as the starting material. The extrusion process has a cost advantage since the spinning process uses isolated proteins (90% protein) as the starting material.

In the extrusion process, soy flour is mixed with water, sodium chloride and other ingredients. The mixture is passed under pressure through a cooker extruder. The product expands as it leaves the extruder die and forms the textured vegetable protein product. The size and shape of the extruded material is controlled by the size and speed of the cutting knife on the extruder. The sized textured protein product is then dried and packaged for shipment. Ingredients such as colors, flavors, seasonings and nutitional additives can be added to textured proteins used in the canning industry.

Spun soy protein products are made by spinning isolated soy protein into fibers much like spinning nylon. The spun fibers are produced by solubilizing isolated soy protein in an alkaline medium. The protein solution is passed through a spinneret to form fibers which are coagulated in an acidic bath. The coagulated fibers are then stretched by a series of rolls moving at increasingly faster rates. Binders such as egg albumin are added to hold bundles of fibers together. Colors, flavors and other ingredients similar to those used in textured soy flour are added to make the finished product. The spun fiber based products are more expensive than extruded soy products because of the more expensive process and starting material. For this reason, they are generally sold as meat analogs to completely replace meat in specialized markets. Spun soy protein analogs are usually sold frozen as ham, chicken, beef, fish or bacon slices, cubes, bits or granules. The extruded soy flour products are the ones most generally used to extend meat in canned meat products.

TABLE 1

Typical Chemical Analysis of Thermoplastic Extruded Soy Products

Component	%
Protein (N x 6.25)	50
Moisture	7
Ash	7
Fat	1
Carbohydrates (by difference)	32
Fiber	3
	100

Textured vegetable proteins have a PER (Protein Efficiency Ratio) of at least 80% of casein. The soy protein contains all of the essential amino acids. The amino acid lysine is present in substantial levels and methionine is the first limiting amino acid. Methionine can be added to soy protein products to give a PER value equal to casein. The processes involved in fabricating textured vegetable proteins provide the opportunity to incorporate essential nutrients into food products.

The wide variety of textured vegetable proteins available in the market allows the food processor to use these products in many applications. The primary area of usage is in ground meat-containing products. Textured vegetable proteins may be used to extend or completely replace ground meat in canned meat products such as chili, Sloppy Joes, spaghetti sauces, meat stews and meat sauces. It can extend ground meat in canned products such as patties and meatballs.

The USDA permits the use of textured vegetable proteins in canned meat products; however, they specify maximum levels of addition and require a certain amount of meat. Products, such as meatless chili, that use textured vegetable proteins to completely replace meat would not fall under USDA jurisdiction. However, FDA labeling requirements would have to be met.

The USDA has conducted studies with chili, meat stews, meat sauces and barbeque sauces to develop a labeling policy for the use of textured vegetable proteins based on the ratio of fresh meat to the dry soy analog in the product formula. For products in which the fresh meat to dry soy protein is greater than 13 to 1 (13 parts fresh meat to 1 part dry soy protein), the label only need reflect the soy protein in its proper position in the ingredient list. For products with ratios between 13:1 and 10:1, the label should have a qualifying phrase that reads "textured vegetable protein added" or similar wording. For products with formulas having ratios of less than 10:1, e.g., 6 1/2 parts beef to 1 part dry textured soy protein, the label should bear wording that equates the textured vegetable protein with meat ("beef and textured vegetable protein stew" or "textured vegetable protein and beef chili sauce"). The USDA and FDA regulations are changing to reflect new technology; therefore, it is important to consult with the USDA and FDA in conjunction with private legal counsel for the latest regulations.

As mentioned previously textured vegetable protein can be used to prepare meatless canned foods such as meatless chili, meat-like sauces, etc. Textured vegetable protein is generally used at a level of 10-15% in meatless chili. Formulas for meat-like products using textured vegetable protein are usually made up to provide the same protein content in the textured vegetable protein containing product as the level found in the meat based formulation.

Granular or flake-like textured vegetable protein products can be used in canned foods. The particle size of the textured vegetable protein is selected to match the size of meat particles normally found in the product. Large textured vegetable protein chunks are available for meat stews as well as granules to simulate ground meat particles.

Textured vegetable protein can be hydrated in water before adding it to the remaining ingredients or it can be added dry and allowed to hydrate in the liquid present in the formulation. Most textured vegetable protein products will absorb 2-3 times their weight in water or other liquids. Textured vegetable protein will absorb some fat, thereby reducing the free fat in the canned product. It is important to provide enough liquid for hydration so that the finished retorted product will have an acceptable consistency.

The extruded textured vegetable protein products offer an attractive economic advantage in partial replacement or extension of meat products. An example is the use of hydrated (2:1) textured vegetable protein into ground beef at a 25% repiacement level. This results in savings based on the ingredient costs.

Other advantages of the use of textured vegetable proteins in canned food products include the following:

1. The extruded products are dried to less than 8% moisture and under normal storage conditions have a shelf life of about one year. Freezers or cold storage are not required.

2. Textured vegetable proteins can be fortified with vitamins, minerals and other supplements to provide balanced nutrition in the final canned product.

3. Textured vegetable proteins maintain their structure upon hydration and provide a meat-like texture.

4. They normally absorb 2-3 times their weight in water. They also have good fat absorption properties.

5. They have low bacteria counts in comparison to meats.

6. The products can be colors, flavored and sized to resemble a wide variety of food products.

7. They allow canners a means of making meat-like canned products in the off-season and thereby allowing year around utilization of equipment.

As the price of meat increases, the use of textured vegetable proteins in canned meats and related products should continue to expand.

MONOSODIUM GLUTAMATE

Glutamic acid, being one of the most common amino acids, is a constituent of almost all proteins. Although a non-essential amino acid, it is an important source of nitrogen and may also act to conserve the essential amino acids against depletion.

A number of salts of glutamic acid can be used in food preparation, however the sodium salt of glutamic acid–monosodium glutamate (MSG) is usually used for enhancing, balancing, blending and generally rounding out flavors–all without its presence being obvious. Therefore, MSG is widely used as a flavor enhancer in both family food preparation and in commercial food processing. Other cationic forms such as the K^+ and NH^+_4 salts are also available.

Glutamate occurs naturally in varying amounts in many foods including milk, meat, fish, poultry and vegetables. There tends to be a high free glutamate content in foods that have a relatively strong flavor. Mushrooms and soup stocks are cited as being exceptionally high in free glutamate. It is suggested that high free glutamate content may be one of the reasons mushrooms enhance the flavor of foods to which they are added. The superior flavor of young, freshly harvested vegetables may be due to higher glutamate content when compared to older samples. Although the mechanism(s) by which glutamate acts as flavor enhancer is unknown, it is believed it may be associated with foods losing a considerable amount of their free glutamate content during the first 24 hours after harvesting, causing a concomitant loss of flavor.

Similarly, it has been observed that numerous food processing procedures (washing, blanching, cooling, exhausting and cooking) cause loss of some of the soluble natural components, including water soluble proteins, vitamins, minerals and amino acids including glutamate hence, a marked loss of flavor in foods. Thus it has been suggested that addition of glutamate in processing or at the table is a replacement of depleted naturally occurring glutamate. However, glutamate is effective in a variety of products such as meat and poultry where the natural glutamate content is not low.

Monosodium glutamate is made from natural food substances. A fermentation process is generally used beginning with molasses derived from sugar cane or beets. The 6 carbon carbohydrate is transformed to the appropriate 5 carbon amino acid microbiologically. Alternatively, MSG may be extracted directly from sugar beets and extraction from corn or wheat gluten was used years ago. The end product, a fine, white, crystalline salt is sold in the U.S. according to Food Chemicals Codex specifications, and in other countries according to other national and international standards

Although foods that are basically protein in origin are likely to be improved in flavor by the addition of monosodium glutamate, flavor enhancement is also observed in low protein recipes such as those vegetable-based. Thus effective application ranges from meats, and poultry, to seafoods, soups and vegetables. Conversely, addition of MSG to foods such as fruits, fruit juices, candy and cereal products does not indicate improvement in flavor. Degree of acidity of the food also effects the amount of flavor contributed by MSG. Generally speaking, the higher the acidity of the foods, the lower the effectiveness of MSG as a flavor enhancer.

MSG is effective in maintaining the flavor of foods from the time of processing to consumption. Widely used for three decades in the U. S. and longer in the Orient, MSG has long been recognized as an effective flavor enhancer by food processors, and has been used in such canned foods as meats, soups, soup bases, gravy, etc., in addition to frozen, and dehydrated formulations. Glutamate does not require a special technique for its use, being added at the same point in the process that salt, spices and sugar are normally added.

A major area of application of monosodium glutamate is in the commercial production of canned, dehydrated, condensed, or frozen soups. The addition of MSG to soups and stews gives them a more full-bodied, blended flavor.

Monosodium glutamate, being popular in a variety of cuisines, is a common commodity in international trade and enjoys particular popularity in the Orient, Europe and the Americas. Consequently, standards on the food use of MSG have been established by both national and international regulatory agencies.

MSG is on the list of Substances Generally Recognized as Safe (GRAS), 21 CFR 121.101, which along with regulated food additives governs the use of most food ingredients, components and additives used in the United States. Thus, MSG is regulated into the same category as salt, pepper, sugar, vinegar and baking powder.

In addition various standards of identity govern the use of glutamate in numerous foods as listed below:

STANDARDS OF IDENTITY CODE OF FEDERAL REGULATIONS

VEGETABLES – TITLE 21

Food	*Section*
Peas	51.1
Beans	51.10
Beans, Wax	51.15
Corn	51.20
Omnibus	51.990

MEATS – TITLE 9

Chopped Ham	319.105
Corned Beef Hash	319.303
Omnibus	381.147

Internationally, the Food and Agriculture Organization/World Health Organization (FAO/WHO) has established an Acceptable Daily Intake (ADI) for monosodium glutamate of 120 mg/kg body weight for humans over the age of 12 weeks.

WATER SOLUBLE GUMS (HYDROCOLLOIDS)

The range of ingredients and products made more useful in their various applications through the use of gums or hydrocolloids would be startling to the average consumer, but should not come as a surprise to the food technologist who is interested in improving his products.

The vegetable gums, or natural plant hydrocolloids, have served for centuries as foodstuffs, as well as thickeners and extenders of other foods.

The chemical components of gums are present in almost every natural food and are largely responsible for the structure and textural properties of the plant.

All food processes, by their very nature, involve some modification or denaturation of the characteristic food texture which results from a change in the moisture content or the physical state of water. Either the moisture is partially or wholly removed, as in dehydrated foods, or it is changed physically to the gaseous state as in cooking and blanching operations, or to the solid state as in freezing processes. It is evident that a change in the amount of water or in its physical states is largely responsible for alterations in the texture of the processed food product.

Plant hydrocolloids, by definition, are water loving materials which can influence the processing conditions and behavior of a food product in several ways.

The most important functions performed by gums in processed food product formulations are:

Retention of water;
Reduction in moisture evaporation rates;
Alteration of freezing rates;
Modification of ice crystal formation;
Regulation of rheological properties or viscosity

Table 1 lists the many functions of plant hydrocolloids in foods and provides an example of each.

There are many factors that need to be considered when selecting a hydrocolloid, such as:

(a) Viscosity required,
(b) Gel characteristics, if any,
(c) Emulsification required,
(d) Rate of hydration,
(e) Dispersion problems,
(f) Mouth feel,
(g) Processing conditions, including temperature,
(h) Particle size requirements,
(i) Availability and cost at the required use level.

Table 2 summarizes the natural plant hydrocolloids and describes the typical characteristics of each hydrocolloid and lists the major food applications for which they are currently being used.

Agar is used as a binding and gelling agent in canned pet foods and various prepared icings and cake decorating agents.

TABLE 1 FUNCTIONS OF PLANT HYDROCOLLOIDS IN FOODS

FUNCTION	*EXAMPLE*
Adhesive	Bakery Glaze
Binding agent	Sausages
Calorie control agent	Dietetic foods
Crystallization inhibitor	Ice cream, sugar syrups
Clarifying agent (fining)	Beer, wine
Cloud agent	Fruit juice
Coating agent	Confectionery
Emulsifier	Salad dressing
Encapsulating agent	Powdered flavors
Film former	Sausage casings, protective coatings
Flocculating agent	Wine
Form stabilizer	Whipped toppings, beer
Gelling agent	Puddings, desserts, aspics
Molding	Gum drops, jelly candies
Protective colloid	Flavor emulsions
Stabilizer	Beer, Mayonnaise
Suspending agent	Chocolate milk
Swelling agent	Processed meats
Syneresis inhibitor	Cheese, frozen foods
Thickening agent	Jams, pie fillings, sauces
Whipping agent	Toppings, icings

TABLE 2 CHARACTERISTICS OF PLANT HYDROCOLLOIDS

HYDROCOLLOID	*MAJOR APPLICATIONS*	*TYPICAL CHARACTERISTICS*
Agar	Icings, glazes	Forms firm gels at 1% concentration
Alginates	Desserts, ice cream and ices, beverage emulsions	Low viscosity emulsifier
Arabic	Bulking agent, beverage emulsions, protective colloid, and beverages	Good emulsifier, low viscosity, up to 50% concentration
Carrageenan	Milk reactivity, ice cream desserts	Milk reactivity
Furcelleran	Desserts, flans	Firm gels without refrigeration
Ghatti	Heavy emulsions	Moderate viscosity good emulsifier
Guar	Ice cream, pet foods, sauces, processed cheese	Viscous solutions, suspending agent
Karaya	Ices and ice cream	Acid resistant, good adhesive
Locust Bean Gum	Ice cream, sauces, bakery products, processed cheese	Solutions must be cooked to develop full viscosity
Tamarinds	Confectionery, jujubes, ice cream stabilizer	Low viscosity
Tragacanth	Pourable dressings, bakery emulsions, sauces	Emulsifier, acid resistant

Arabic is used as a stabilizer in a wide variety of oil in water flavor emulsions which are prepared for beverage and baking industry.

Ghatti is used as an emulsifier of butter in butter syrups for pancakes.

Carrageenan is used for its milk reactivity or reaction with proteins as an ice cream stabilizer, canned chocolate syrups and toppings, canned custards, yogurt and puddings as well as icings. It is also used as a stabilizer in canned concentrated evaporated milk.

Furcelleran is used similarly to carrageenan but more importantly as a gelling agent to modify some of the above products.

Guar gum is used for its water binding suspending properties and stabilizing ability in ice cream, canned pet foods, canned sauces, syrups, toppings, custards, and puddings.

Locust bean gum is used similarly to guar gum but requires heat to about 180°F for 15 minutes to completely solubilize it, whereas guar is cold water soluble.

Tragacanth is used as a thickener, stabilizer and emulsifier in a variety of pourable dressings, oil in water flavor emulsions and a variety of sauces.

The U.S. Food and Drug Administration has cleared these gums and they are listed as "GRAS". However, they may not be used where precluded by Standards of Identity Regulations.

XANTHAN GUM

Xanthan gum is a relatively new hydrocolloid to the food industry, having been approved for use by the Food and Drug Administration in 1969. Since then a number of food uses have developed including a number of uses in canned products.

Xanthan gum is a high molecular weight polysaccharide which is produced by the action of the microorganism *Xanthomonas camnestris* on dextrose. The fermentation is carried out aerobically under stringent controls and the gum is recovered by precipitation with isopropyl alcohol. The resultant product produces high viscosity water solutions which are pseudoplastic, unusually stable to high temperatures and change viscosity very little with changes in temperature. Xanthan gum is compatible with a wide range of salts, acids and bases and with higher concentrations of these materials than most other thickeners. Xanthan gum also forms thermoreversible gels when combined with locust bean gum.

Xanthan gum has been used widely in pourable salad dressing and as a necessary ingredient in the production of heat stable salad dressing. At a level of about 0.4% xanthan gum produces a dressing that can be retorted at 240°F for application in canned meat salads. It is also used to stabilize and improve the texture of canned puddings as well as low pH milk products such as sour cream, chip dips, cheese cake and yogurt. Canned sauces of all types are improved by the addition of small amounts of xanthan gum because of its resistance to thermal degradation and its excellent suspending properties.

Although yet to be examined fully, xanthan gum has shown promise as a process time reducing aid in starch-thickened sauces. Apparently, xanthan gum's high degree of pseudoplasticity results in an instantaneous reduction in viscosity, thus promoting better heat transfer. This is particularly evident in agitating retorts such as the FMC Orbitort.

Xanthan gum was approved as a general food additive without any quantity restrictions by the United States Food and Drug Administration on March 19, 1969 under CFR Title 21, Section 121.1224.

ALGINATES

Algin has been used by the canning industry for many years but it has been only recently, within the last decade, that greater attention has been paid to the unique functionality of this colloid and its derivatives for the development of new technology and products.

Alginates are high molecular weight polymers of the salts of D-mannuronic and L-guluronic acid. They are obtained by the alkaline extraction of a number of brown seaweeds but principally *Macrocystis pyrifera* which grows off the West Coast of the United States. The propylene glycol ester is also produced by the reaction of propylene oxide with alginic acid. The water soluble salts of alginic acid (sodium salt) form viscous solutions which increase in viscosity or gel in the presence of polyvalent metal ions such as calcium.

Sodium alginate has been used in can sealing compounds and as a stabilizer for canned chocolate milk. In the mid sixties propylene glycol alginate came into use as an emulsion stabilizer in canned vegetables such as corn containing butter sauce. The alginate, already well known as an excellent emulsion stabilizer for salad dressing, was used to stabilize a butter in water emulsion which also contained some seasoning. The emulsion provided good dispersion of the butter throughout the product through retorting and when the product was served.

Probably the most unique application of algin in canning was a process in which a low viscosity sodium alginate was allowed to react under controlled conditions with a calcium salt. The results are a substantial reduction in process time and an improvement in product quality. This is accomplished by reformulating a starch thickened sauce by reducing the starch level to one percent from four or five percent and replacing the starch with 0.5-1% low viscosity sodium alginate. An insoluble calcium salt such as calcium carbonate or dicalcium phosphate dihydrate is added to the can just before closing in the form of a slurry for good dispersion. The viscosity at the initial can temperature is only 10-50 centipoises rather than several hundred centipoises as is usually the case. The result is a great improvement in heat transfer during come-up, processing and cooling. After processing, the algin reacts with the calcium to cause a gradual thickening to the desired viscosity; this takes several days in most cases.

As might be expected, the process works best in agitating retorts such as the FMC Sterilmatic or the newer Orbitort where forced convection heating shortens processing even more. In most products, such as stews, chow mein and vegetables and meat in various thickened sauces, process times have been shortened by fifty per cent or more.

The sodium, potassium, ammonium and calcium salts of alginic acid are included in the GRAS (Generally Recognized as Safe) list under Title 21 of the Code of Federal Regulations, Section 121.101 (d) (7)

Propylene glycol alginate is an approved food additive under Federal Register, Title 21, Section 121.1015, since June 29, 1960.

CARRAGEENAN

Carrageenan consists of a group of galactan polysaccharides extracted from red seaweeds of the *Gigartinaceae, Solieraceae* and *Phyllophoraceae* families. The three principal types are referred to as *kappa, iota,* and *lambda.* They differ from one another principally in amount of ester sulfate, the position of the ester sulfate groups, and their 3,6 anhydro-D-galactose content.

Kappa-carrageenan is composed of alternating 1,3-linked galactose 4-sulfate and 1,4-linked 3,6 anhydro-D-galactose residues. It is most sensitive to K^+ ions, in the presence of which it can form rigid, thermally reversible aqueous gels.

Iota-carrageenan is composed of alternating 1,3-linked galactose 4-sulfate and 1,4-linked 3,6 anhydro-D-galactose-2-sulfate residues. It is most sensitive to Ca^{++} ions in the presence of which it may form elastic, thermally reversible aqueous gels.

Lambda-carrageenan is composed of alternating 1,3-linked galactose (about 70% contain 2-sulfate) and 1,4-linked galactose 6-sulfate residues. *Lambda*-carrageenan is nongelling regardless of the cations with which it is associated. Carrageenans are widely used in food applications for their suspending, stabilizing, thickening and gelling properties. Moreover, the unique ability of carrageenan to complex with milk protein has resulted in the development of numerous milk-based applications.

Legal Status—Carrageenan is a regulated food additive as given in Federal Register, Title 21, Section 121-1066.

USES IN CANNED FOODS

Evaporated Milk—*Kappa*-type carrageenans are effective in preventing fat separation at levels of from 0.005 - 0.01% by weight of the finished product.

Infant Formulas—*Kappa*- or *iota*-carrageenan stabilizes the protein and prevents fat separation at levels of from 0.02 - 0.04%.

Chocolate Milk, Eggnog, etc.—In canned products of this type, *kappa*- or *iota*-carrageenans are used at levels from 0.01-0.035% to maintain ingredients such as cocoa in suspension, prevent separation of fat and impart a rich mouthfeel.

Canned Puddings–Iota-carrageenan, at a concentration of about 0.10%, is used as a partial replacement for starch to reduce cook viscosity, control syneresis and impart improved mouthfeel and flavor release characteristics.

Pet Foods–Kappa-carrageenan at 0.1-0.3% serves to prevent fat separation and thicken or lightly gel the gravy.

Dessert Gels–A combination of *kappa-* and *iota*-carrageenan serves as a gelling agent at a combined total of about 0.75% for preparation of canned dessert gels that do not require refrigeration.

Fish Gels–Canned fish encased in a *kappa/iota* carrageenan gel of 0.5 - 0.75% concentration has improved flavor with condiments uniformly suspended.

Aerosol Products–Canned whipped toppings utilize *kappa-* or *lambda*-carrageenans to stabilize overrun and control syneresis at levels ranging from 0.03 - 0.10%.

GELATIN

Gelatin has been defined as a refined extract of collagenous tissue which forms clear, viscous solutions in water, or simply, a protein of high purity. It probably is one of the most versatile raw materials available today. The broad versatility can best be emphasized by pointing out its primary functions are as a gel-former or as a protective colloid; but that it also can serve as a clarifier, binder, film-former, flocculator, thickener, moistener, texturizer, emulsifier, disperser, strengthener, air-entrainer, softener, tenderizer, foamer, tableter, imbibing agent, and protein source.

The most important property of gelatin is its function as a hydrocolloid. Gelatin is a superior protective colloid because of its particular chemical and physical structure. It is amphoteric. It forms a true sol in water. It remains soluble through the entire range of pH, unless tanned. Its solutions form thermally reversible gels.

Gelatin is extracted from animal tissues which contain high proportions of white connective tissue (collagen). The tissues extracted commercially are skins, sinews, and bones. Gelatin may be extracted directly from these tissues by boiling water, but the rate of extraction and quality of gelatin are greatly improved by pretreating the collagenous tissue.

The pretreatment (cure) may be a prolonged soak in saturated lime (calcium hydroxide), or an adjustment of pH by a soak in acid solution. The pretreatment also is used as the basis for classifying gelatin. "Type A" is gelatin derived from acid-cured tissue. "Type B" is gelatin derived from lime-cured tissue.

Gelatin is extracted from the cured tissue by a number of applications of water at progressively higher temperatures. Each successive extraction yields gelatin of low jelly strength and viscosity. Since a higher proportion of gelatin is extracted in the early extractions of acid-cured skins, the proportion of high-test, "Type A" gelatin available to the customer is much greater than "Type B" gelatin

Demineralized bones and hide trimmings respond better to the lime cure, while porkskins respond better to the acid cure. Most "Type S" gelatin is derived from porkskins.

The gelatin molecule is made up of amino acids joined together in a long molecular chain. There are 18 different amino acids in gelatin, each occurring in its own level and sequence.

GELATIN DESSERTS

Gelatin is particularly suited to gelatin desserts, because it forms a sparkling clear jelly which does not synerize (bleed) and has a crisp, clean mouth feel that is not attained by any vegetable hydrocolloid.

Gelatins vary in their behavior in gelatin dessert formulas. A good gelatin for desserts should impart fast set to a firm jelly within two or three hours in the refrigerator, but should not be too firm in 24 hours, and should produce a clear, sparkling jelly at the pH of the dessert.

A gelatin dessert powder consists of a sweetener, gelatin, food acid, a buffer, salt, color, and a flavor. The amount of gelatin in the formula depends on the intended use, and on the jelly strength of the gelatin, but generally falls in the range of 8 to 10% of the total dry weight. Desserts for instituitional use require a higher level of gelatin to maintain a firm jelly at room temperature, than do finished desserts held under refrigeration for long periods in display cabinets.

Since gelatin desserts are adjusted to low pH to attain tartness, a gelatin which retains its jelly strength a low pH is very desirable.

Typical ingredients for a flavored gelatin dessert mix are the following.

TYPICAL GELATIN DESSERT FORMULA

Gelatin	8-12%
Food Acid	2-3%
Buffer Salts	0.6-1%
Salt	0.3%
Flavor and Color as desired	
Sucrose (table sugar) to	100%

Three ounces of the above mixture will gel one pint of liquid after setting two to three hours at refrigerator temperatures.

The gelatin is listed as a variable quantity, since gelatin dessert manufacturers use a variety of gel strengths. The lowest percentage requires gelatin of the highest gel strength. The gel strength of gelatin used in dessert blends varies from 175 to 300. The setting quality of the dessert is affected by the gel strength, concentration, viscosity, and pH of the gelatin. Either Type A or Type B gelatin, blended in the above mixture, produces excellent gelatin desserts.

A food acid, such as citric, is used to impart tartness to the finished dessert. Buffer salts, such as sodium citrate, are added to help maintain the desired level of acidity (pH). Some buffers may possibly accelerate setting time. An excess of acid may interfere with the setting and melting characteristics. Buffer salts permit the addition of enough acid to impart tartness without adversely affecting setting rate. Salt is added to help accentuate the flavor. Manufacturers are cautioned to seek the advice and guidance of reputable suppliers for their flavors and colors. An otherwise superior product can be ruined by the selection of an inadequate color and a deficient flavor.

The sugar in the formula need not be restricted to either beet or cane sugar. In many blends, dextrose is also used. In dietetic or low calorie desserts, the sugar is replaced in part, or completely by artificial sweeteners.

Fruits and vegetables can be suspended in the partially set dessert. Fresh pineapple and papaya should be avoided since they contain enzymes which hydrolyze the gelatin and prevent gelling. In the preparation of the finished dessert, the water added with the fruit, fresh or canned, or vegetables must be taken into consideration. Failure to compensate for this addition, usually results in a weak and flaccid dessert which requires a longer than usual gelling time. The dessert is readily dissolved in warm (150°F) water, during a few minutes stirring. When removed from the refrigerator, a gelatin dessert is sparkling, colorful and pleasing to the taste.

JELLIED MEATS

The purpose of gelatin in jellied meats is to gel the fluids around the meat and act as a binding agent.

Clarity is an important property in such products as headcheese and jellied tongue. The amount of gelatin to use in such products depends upon the original grade (Bloom strength) of the gelatin used and the amount of liquid used to surround the meat particles. With a high-test product, as little as 2-1/2 lbs. per 100 lbs. of meat can be used. On the other hand, with a low-strength gelatin, as much as 4-1/2 lbs. per 100 lbs. of meat may be needed. The amount of liquid or broth used to suspend the meat usually runs between half to three-quarters of the meat weight. The more broth used, the more gelatin is needed to maintain the desired strength of gel.

Gelatin is used in binding the juices which exude from the muscle tissues when canned hams are produced. Again, the amount of gelatin to use to bind the liquid will depend upon its grade, or Bloom strength. The amount will also depend upon the heat processing given to the hams, since gelatin tends to lose strength under heat processing. Although the actual gel loss is greater with high-test material than it is with a lower grade, the proportion of loss is the same in both cases. Thus, the economies for proportion of one product to use in comparison to the other will be based upon the normal ratios of usage level. The usual level of gelatin to use for a 10-lb. ham is about 1 to 2 oz.

CLARIFICATION OF BEVERAGES

The tendency of gelatin to coacervate with other proteins and hydrocolloids makes it useful for precipitating such materials from the beverages and thus clarifying them. Gelatin is used in the clarification of beer, wines, vinegar, apple juice, and other juices.

EMULSIFIERS

Emulsifiers are widely used in many foods, including canned items. They may be broadly classified by the function they serve in the food. Typically they are used as solubilizers, emulsifiers and demulsifiers, detergents, crystallization modifiers, foaming and defoaming agents, wetting and lubricating agents, and complexing agents. In canned foods, as in others, many of these uses tend to overlap.

Emulsifiers usually act to alter the surface properties of materials they contact, hence the synonym "surfactants". The emulsifier or surfactant molecule is composed of a water-loving (hydrophilic) and a fat-loving (lipophilic) portion. When fat and water are mixed the emulsifier orients across the interphase, i.e., lines up between the two liquids with its lipophilic portion in the fat and the hydrophilic portion in the water. By bridging the two immiscible liquids the emulsifier can maintain a stable dispersion of one liquid in the other. The size and strength of the hydrophilic and lipophilic components determines the HLB (Hydrophile-Lipophile Balance) value of the surfactant. Lipophilic surfactants have low HLB values (2-9) while hydrophilic surfactants have high values (greater than 11).

The origin of a surfactant may be either synthetic or natural. Eggs, milk, meat, mustard, and soybeans are examples of natural foods which contain surface active materials. Synthetic emulsifiers are produced from a wide variety of edible materials. Use of both natural and synthetic emulsifiers is restricted to those materials which are "generally recognized as safe" (GRAS) by the U. S. Food and Drug Administration, or proved safe so that a petition for a specific application may be submitted to the FDA. Canned products containing meat or poultry, and packed under the supervision of the United States Department of Agriculture, may contain only those emulsifiers which have received USDA approval for the intended application.

Use of emulsifiers has shown a slow but steady increase as consumers and processors have developed an interest in more sophisticated canned foods. The addition of dill oil to processed pickles and pickle products requires an emulsifier to solubilize the oil in the brine. A hydrophilic emulsifier like polysorbate 80 is used at a level of about 2 parts to 80 per part of dill oil to provide a clear solubilization of the dill oil in the brine. Orange oil used to flavor canned orange drink and soda is similarly solubilized with a hydrophilic emulsifier.

Formation of a stable salad dressing emulsion can be accomplished using a combination of a hydrophilic emulsifier such as polysorbate 60, and a thickener. In pourable dressings a thickener such as xanthan gum is used at 0.4-0.6% while the emulsifier is used at 0.3% of the formula. Spoonable dressings such as imitation salad dressing and imitation mayonnaise can be formulated without egg by the use of a thickener/emulsifier system. Elimination of egg minimizes cost variations, bacterial problems, and cholesterol content. Imitation salad dressing is prepared in the normal manner except that a moderate increase in starch is required and a small amount of emulsifier is used in place of the egg. The thickening property of egg is replaced in imitation mayonnaise by a stabilizer such as xanthan or a low level of cooked starch. In both types of spoonables a hydrophilic emulsifier like polysorbate 60 is used for emulsification at 0.3% of the finished dressing. Artificial color and flavor are used as desired.

Not all surfactant roles involve emulsification. For example, the amylose released from spaghetti during retorting may result in a slumped, gelled mass of partially disintegrated strands. Monoglycerides can complex or tie up the amylose to minimize these defects. In canned bread the monoglyceride/ amylose complex helps maintain a soft crumb structure during the long shelf life of this product. Typical use levels for monoglycerides in these applications is 0.5-1.0% of the flour weight, added to the dough.

Another non-emulsifying role for surfactants is in stabilizing the oil in peanut butter. Peanut butter contains much free oil which tends to separate in a relatively short time. To overcome oil separation, 1 - 2.5% fully hydrogenated mono and diglycerides are added with the sweetener to crystallize a portion of the free oil, thereby preventing oil separation. In consumer shortenings 2.5 - 3% plastic mono and diglycerides and 0.5% of a hydrophilic emulsifier like polysorbate 60 may be included to give smooth, well aerated icings and light, tender cakes. Bottled salad oil containing 0.5% of a hydrophilic emulsified such as polysorbate 80 exhibits marked improvement in emulsion stability when used by the consumer for home-made salad dressings.

In canned products containing meat, a continuing problem is the accumulation of rendered fat at the top of the product. Because the fat is not freed until retorting takes place, prevention of the fat cap is difficult. The most effective technique for minimizing the problem with emulsifiers is to thoroughly blend the emulsifier as intimately as possible with the meat prior to retorting. Materials such as 0.1 - 0.2% sodium stearoyl-2-lactylate or 0.25 - 0.5% hard mono and diglycerides are recommended.

It is difficult to predict which surfactant will solve foaming and defoaming problems. In the formulation of liquid cocktail mixes or "frothers", hydrophilic emulsifiers such as polysorbate 60 act as a very effective foaming agent. The use level varies from as much as 3% in the concentrated "frother" to as little as 0.15% in a sour mix requiring only the addition of liquor.

Whereas the hydrophilic polysorbate esters are used as foaming agents, lipophilic glycerol mono-oleate acts as a defoamer. In the production of jellies and jams 20-50 ppm of glycerol mono-oleate is added to break the foam which would ordinarily occur during boiling.

The common types of emulsifiers which are approved for food use are: Glycerol esters, polyglycerol esters, propyleneglycol esters, glycerol-lacto esters, phosphated glycerol esters, sorbitan esters, polyoxyethylene sorbitan esters, lactic acid esters, and lecithin.

COLORS

Coloring agents affect the aesthetic value of food products. The color of a food, and to a certain extent the texture, are the first impressions received by consumers and can be extremely important in determining selections among competitive products. Color differences from the norm are, in fact, often overweighed by the consumer in his evaluation of the quality of a product.

The 1960 Color Additive Amendments to the Food, Drug, and Cosmetic Act established two classifications: Certified and uncertified food colors. The former are coal tar derivatives which are manufactured by chemical processes, while the latter are primarily natural colors and their synthetic analogs.

The Color Additives Amendments brought all colors, not just coal-tar colors, under the jurisdiction of the law. Likewise, it required re-evaluation of all colors, even those previously listed and certified as harmless. It also allowed FDA to set limits on the amounts of color used. The same law states that no color can be used if its use promotes deception of the consumer. In other words, if it is used to cover a blemish, to conceal inferiority, or to mislead the consumer in any way. The spice saffron, for instance, cannot be used commercially as a coloring matter in a way that would lead purchasers to think they were buying an egg-rich product.

Uniform compositional standards have also been established for color additives and there is provision for certification of manufacturer's individual batches of color, through chemical testing by the FDA, to insure purity and safety.

In addition, the Amendments established two lists of approved certified color additives: a permanent list, and a provisional list for color additives which had not been sufficiently investigated as to their suitability for permanent listing. The Delany cancer clause is also contained in these Amendments. This clause forbids the listing of any color additive at any concentration which has been found to induce cancer in man or animals. It also permits the appointment of a scientific advisory committee to make recommendations in cases invoking the cancer clause.

If a food contains any artificial, i.e., non-natural, coloring the law deems the product misbranded unless its labeling states this fact. There are exceptions to the law, for example, which concerns the labeling of butter, cheese, and ice cream. This exception applies solely to artificial coloring agents for these products.

FOOD COLORS EXEMPTED FROM CERTIFICATION OR UNCERTIFIED FOOD COLORS

The uncertified food colors are either natural in origin or synthetic duplicates of the natural compound. A partial list of the FDA-approved list of these colors includes the following as of this writing:

Annato Extract
Beta-Carotene
Beta-Apo-8'-Carotenal
Caramel
Grape Skin Extract
Paprika & its oleoresin
Saffron
Xanthophyll
Fruit juice
Vegetable juice
Riboflavin
Canthaxanthin
Carbon black (Channel black only)

Turmeric & its oleoresin
Beet Powder
Titanium Dioxide

Carmine or cochineal extract
Dried algae meal
Ferrous Gluconate
Tagetes (Aztec marygold)
Ultramarine blue
Corn endosperm oil
Carrot oil
Toasted partially defatted cooked cottonseed flour

Annato, beta-carotene and beta-apo-8'-carotenal are employed to color margarine, butter, ice cream, cheese and most other dairy type products. Paprika is the only coloring agent permitted in French dressing. Caramel is extensively used to enrich the color of meat products and rye bread, and to color root beer and cola type beverages. Carbon black is used for coloring licorice candies. Titanium dioxide is used in coloring some coffee whiteners, sandwich spreads and candies where whitening is required. Beet powder is used in instant gravy preparations along with caramel. Ferrous gluconate can only be used to color black olives.

Certified Colors

There are two main types of certified colors – dyes and lakes. Dyes are materials which manifest their coloring power by being dissolved in a liquid or solvent.

Lakes are pigments or insoluble forms of the dyes. The lakes show their coloring power in the dry state and color by dispersion. The FD&C lakes are merely alumina hydrate (aluminium hydroxide) on which the dye has been adsorbed.

The FD&C dyes are water soluble and are insoluble in nearly all organic solvents. Water solubility of most colors is quite high and in most application methods solubility is usually no problem. FD&C Blue No. 2 (Indigotine) is the exception to this, and often it would be advantageous to have a greater solubility for FD&C Red No. 40.

For systems where anhydrous conditions are a consideration, glycerine and propylene glycol are used as solvents. In general, the colors are more soluble in glycerine than in propylene glycol. Most are only very slightly soluble in ethyl alcohol, but use is often made of the reasonable solubility in alcohol of FD&C Red No. 3, FD&C Blue No. 1, and FD&C Green No. 3.

Good coloring technique recommends that the dyes be solubilized before addition to the colored product. However, it is often possible, where water is added in the process, to add the dry color to the batch and depend upon the added moisture and heat to dissolve the color in processing.

Dyes may be purchased as powder, granular, plating colors, wet-dry (blends), diluted (cut blends), liquid (aqueous), liquid (non-aqueous), and paste. The best form for any specific use will be dictated by the nature of the product, the process conditions employed and the amount of color used.

Classification Of Certified Food Colors

Certified colors currently approved by U. S. Food and Drug Administration for use in foods are classified in two groups. These groups include (a) the permenently listed colors, and (b) the provisionally listed colors. The two tables that follow present the colors currently included in each list.

Current List of Certified Colors Permanently Listed Under the 1960 Color Amendments to the FD&C Act for Use in Foods
Citrus Red No. 2 (approved only to color skin of oranges that are not intended or used for processing)
Orange B (approved only to color casings or surfaces of frankfurters and sausages)
FD&C Blue No. 1
FD&C Red No. 3
FD&C Red No. 40
FD&C Yellow No. 5

Current List of Certified Colors Provisionally Listed Under the 1960 Color Amendments to the FD&C Act for Use in Foods
FD&C Green No. 3
FD&C Yellow No. 6
FD&C Red No. 2
FD&C Red No. 4 (approved only to color Maraschino cherries
FD&C Blue No. 2
Lakes of all the colors listed above

Problems with Food Colors

In using colors many problems may be encountered such as those discussed below.

Problems	*Probable Cause(s)*
Precipitation from color solution or colored liquid food	(1) Color's solubility limit was exceeded (2) Not enough solvent was used (3) Unexpected chemical reaction took place (4) Low temperatures were employed especially for concentrated color solution
Dulling effects instead of bright, pleasing shades	(1) Too much color was used (2) Color was exposed to high temperatures
Specking and spotting during coloring of bakery and confectionery products	(1) While making a solution color was not completely dissolved (2) Liquid color containing sediment was used (3) Attempted to disperse an aqueous color solution in products containing too much fat
Fading due to light	(1) Colored products were not protected from sunlight
Fading due to metals	(1) Contact of color solutions or colored products with certain metals (zinc, tin, aluminum, etc.) was not avoided during dissolving, handling, or storing
Fading due to micro-organisms	(1) Not thoroughly cleaned Color-preparing facilities not clean enough to avoid contaminating reducing organisms
Fading due to excessive heat	(1) Excessive processing temperature was used
Fading due to oxidizing and reducing agents	(1) Color reacted with oxidizers such as ozone or hypochlorites or reducers such as SO_2 or ascorbic acid
Fading due to strong acids or alkalis	(1) The presence of such strong chemicals during the coloring of certain foods was encountered
Fading due to retorting with protein material	(1) Color used did not possess good stability under these conditions
Poor shelf life with colored canned carbonated beverages	(1) An excessive amount of certified azo-type dye was used

Use of Certified Colors in Processed Foods

As a general guideline, FD&C dyes and lakes can be used in any food product unless otherwise prohibited by special regulations such as standards of identity.

1. *Fruit Products*

The use of FD&C Red No. 4 and other FD&C colors in the coloring of maraschino cherries is widely known and well documented. Presently, there is a limitation on the use of FD&C Red No. 4 in cherries at 150 ppm in the finished drained fruit. To achieve this level of color in the finished maraschino cherries, color manufacturers are recommending approximately 1-1/4 ounces per barrel of cherries. If other FD&C colors are used, such as Yellow No. 6, or Red No. 3, it is suggested that the sulfur dioxide content not exceed 100 ppm.

The use of FD&C Red No. 3 in coloring cocktail cherries is well known to the trade. Its use ranges from 1 oz. to 6 ozs. per 1,000 lbs. of cherries. The advantage of this color is that it can be set (precipitated) by citric acid and the color is therefore non-bleeding in the cherries. While non-bleeding cherries of other shades are desired, the prospects are not bright for development of such non-bleeding colors due to the nature of the remaining FD&C dyes.

Apple rings, crabapples, and flavored apple sauces are being colored with combinations of FD&C water soluble dyes. Combinations of 60 parts FD&C Red No. 2 and 40 parts FD&C Yellow No. 6 are being used, and some FD&C Red No. 3 can be used for improved brightness. Four or five ounces of color per 100 gallons of syrup is a suggested color level. In flavored applesauces, 1 to 3 ounces of color per 1,000 lbs. is used to suggest the flavor that is combined with the applesauce.

2. *Pickles and Relishes*

Because of its cost, its variability, its low flavor value, and its lack of light stability, turmeric is being replaced in some pickles and relishes. Recent laboratory trials indicate that FD&C Yellow No. 5 can replace turmeric at the rate of 1 ounce of certified color for one pound of turmeric. For those desiring certified colors for relishes, a combination of:

FD&C Yellow No. 5	–	2 parts
FD&C Blue No. 1	–	1 part

used at the rate of 0.1 oz. to 1 oz. per 100 gallons of brine is particularly useful. If this blend is too bright or artificial looking, then the addition of a small amount of FD&C Red No. 2 is useful.

3. *Paprika and Other Colored Spiced Replacements*

Because of the cost and variability of oleoresin paprika, many food processors are replacing it in non-standardized food products. Color manufacturers have a good deal of information available regarding the replacement of paprika in many products. The economics for replacements of oleoresin paprika are decidedly in favor of certified color. One part of certified color will replace 7 to 8 parts of oleoresin paprika in most wet products.

Food processors are encouraged to contact their color supplier who offers the technical service needed. Food manufacturers are also cautioned to check closely with color manufacturers to keep abreast of the regulatory developments.

Food packers and manufacturers should also keep in mind the FD&C Aluminum Lakes which are finding increasing uses in food products.

PRESERVATIVES

One of the most important functions of additives is in the preservation of foods. Chemical preservatives help distribute foods to the consumer with "fresh" flavor and appearance, and with increased resistance to the growth of microorganisms. It has been estimated that one-fifth of the world's food supply is lost by spoilage. Thus, it is in this area of extending the shelf-life of foods that chemical additives have the most significance.

Preservatives may be classified into four types: antimicrobials and antibiotics, both of which control the growth of microorganisms; and antioxidants and sequestrants which help preserve flavor and color. It should be kept in mind that preservatives cannot improve poor quality foods. They can only arrest the deterioration of good quality foods.

MODE OF ACTION OF PRESERVATIVES

The mechanisms whereby chemical preservatives inhibit the growth of microorganisms are not fully understood. Most studies in this field have been directed towards determining the efficiency of a particular preservative in a given type of food product against a known trial population of microorganisms. These studies have revealed a number of factors that influence the activity of chemical preservatives but, in general, they have not been designed to determine how the metabolism of the microorganism is affected. When this knowledge is obtained, it could lead to the use of more efficient techniques in chemical preservation. Comparatively recent studies on the major preservatives, benzoates, sulphur dioxide, and sorbates, have been inconclusive in elucidating the mode of action of these substances. Experimental evidence indicates that the preservatives interfere with many enzymatic processes, both aerobic and anaerobic, which affect the growth rate of both the aerobic and anaerobic microorganisms concerned. It must also be stressed that it is not known positively whether the molecules must actually pass into the microbial cells to produce the whole or part of their growth-inhibiting effect.

Empirical experiments have given valuable information on the factors that influence the efficiency of preservatives. The principal factors are: concentration of the preservative; composition of the food; and type of organism to be inhibited.

In general, the quantities of preservative permitted by regulations are inhibitory rather than lethal to contamination microorganisms. It is therefore essential that the microbiological population of the food to be treated is kept to a minimum by hygienic handling and processing. Permitted levels of preservative will preserve food with a normal microbial load for a useful period but will be ineffective when incorporated into spoiling or grossly contaminated foodstuffs.

Composition of the food is important for two reasons: the pH of the product will determine the concentration of the acidic preservatives existing in the undissociated form, and the chemical constituents of the product will determine the proportion of the preservative that is rendered ineffective by chemical combination. This second point is particularly important when the use of sulphur dioxide is being considered.

It has been reported that the undissociated acid is the microbiologically active portion of the molecule of acidic preservatives. A high pH leads to a greater proportion of dissociated acid and this explains the greater effectiveness of the common preservatives at lower pH.

ANTIMICROBIAL AGENTS

Antimicrobials are added to foods to prevent or retard the growth of yeasts, molds, and bacteria during storage, distribution, and use in the home. These organisms are a common source of food spoilage and some are a potential danger to our health if they grow to large numbers in the food.

The mechanism of antimicrobial action is not completely understood, but it is thought that they react with the cell to prevent its development and further reproduction.

Common antimicrobial agents used in foods are listed below.

ANTIMICROBIAL AGENTS
Benzoic acid and sodium benzoate
Methyl and propyl p-hydroxbenzoates (Parabens)
Sorbates
Propionates
Sulfites (sulfur dioxide)
Nitrites

Benzoic acid and its salts are the most effective agents against yeast and bacteria in foods which are relatively acid in nature (2.5 - 4.0 pH). They are used in most carbonated beverages, fruit drinks, jams, jellies, and salted margarines at levels of 0.05 to 0.10%.

The Parabens are derivatives of the benzoates and extend their activity into the neutral range of pH or higher. They are generally more active against molds and yeasts than bacteria. They are often used in conjunction with sodium benzoate for similar applications.

The sorbates are generally most effective against yeasts and molds and are widely used to control the growth of these organisms in cheeses, dried fruits, wines, beverages, pickles, etc. They cannot be used in yeast-raised baked goods, but are satisfactory where leavening agents are employed. They impart less of a bitter taste than the benzoates and are more effective at higher pH's. Sorbates are often applied to cheese products by dipping them in a relatively concentrated solution to obtain maximum protection at the surface against molds.

The propionates are widely used in bakery products as a mold and rope (a bacteria) inhibitor at levels of around 0.2%. They are preferred to other agents in these products because they do not greatly inhibit the action of yeast during baking.

Sodium diacetate is sometimes used in bread making as an inhibitor against "rope" bacteria and mold but is rapidly being replaced by the propionates which are less expensive and which have similar activity.

Sulfur dioxide and sulfites are generally employed in the production of wine and is the most effective inhibitor known for fruit juices and dried fruits. It allows the growth of yeast during fermentation and, at the same time, acts as a powerful fungistat and bacteriostat. It also acts as an antioxidant and prevents discoloration of fruits by inhibiting enzymic browning. At present, sulfite is permitted as a preservative in all foods which are not an important source of vitamin B_1.

Nitrites, used in the curing of meats and fish, are reported to have some bacteriostatic activity but are not permitted for this purpose in other foods. There is some question as to the safety of nitrites when used as curing agents in meats.

Diethyl pyrocarbonate (DEPC) was permitted until a few years ago in this country for use as a preservative in wines and in some fruit juices at a level of 0.02% with the stipulation that a maximum of 5 ppm would remain after 24 hrs. after bottling. DEPC is effective in greatly reducing total counts of yeasts and molds in wines and in fruit juices. In most products, DEPC breaks down to ethyl alcohol, carbon dioxide, and water within 48 hours. Because it is used in very small concentrations, up to 0.01%, the amounts of alcohol and gas produced are not of any significance. Another breakdown product formed under normal conditions, urethan, is a known carcinogen. For that reason U. S. Food and Drug Administration has banned the use of DEPC.

ANTIBIOTICS

The antibiotics are much more potent than the other chemical preservatives discussed so far and much interest and hope has been expressed in their utility in food preservation. They possess a much broader range of bactericidal and bacteriostatic properties and are not influenced by pH. Although they are being used to some extent in other countries, there is concern that their wide use can create strains of resistant toxic organisms.

In the past, either oxytetracycline or chlorotetracycline have been used in this country to help preserve uncooked poultry and seafood to extend their marketing life by inhibiting bacterial decomposition. However, they are now prohibited by the FDA for the reason that they were being used as a substitute for good manufacturing practices. Another reason for the ban is that, although those antibiotics are heat labile, a residue may remain in treated foods after cooking.

ANTIOXIDANTS

Antioxidants are employed as additives to prevent two other types of food spoilage – the development of off-flavors from the oxidation of fats, and the deterioration of flavor and color. They also prevent oxidative destruction of many of the vitamins and essential fatty acids in foods.

Most foods, except for fruits and vegetables, contain large amounts of fats. Thus, antioxidants are extemely important to the food manufacturer for the purpose of extending the overall freshness and shelf life of many of his products. An important fact to keep in mind in using antioxidants is that they will not enhance the quality of a deteriorated product, they will only aid in retarding deterioration. Because of the way they function, they are always more effective if added before oxidative changes have had a chance to get started.

The antioxidants approved for food use are listed in the table that follows.

Antioxidants
Butylated hydroxyanisole (BHA)
Butylated hydroxytoluene (BHT)
Propyl gallate (PG)
Gum Guaiac
Tocopherols
Ascorbic acid
Sodium sulfite
Erythorbic acid

The first three, BHA, BHT, and PG, are the only ones in common use in fatty foods in this country. Tocopherols (Vitamin E) are not normally added to foods but are important antioxidants which occur naturally in most vegetable oils. All of these compounds are true antioxidants in that they retard auto-oxidation of materials containing unsaturated bonds, such as occur in polyunsaturated fats, essential oils, and Vitamin A.

Ascorbic acid, sodium sulfite and erythorbic acid are often classed as antioxidants but actually function as reducing agents. They react with oxygen to remove it temporarily from the food system. They are used primarily in fruit and vegetable products to prevent browning and color fading.

When oxidation of fat occurs, the unsaturated bonds in the fat molecule are first activated to a free radical by the action of heat or light. Metal ions such as copper and iron catalyze the formation of these free radicals. The free radical formed is highly reactive, and readily reacts with oxygen to produce hydroperoxides. These are very unstable compounds and easily break down to volatile aldehydes and ketones, which are responsible for off-flavors such as rancid, painty, and grassy.

The true antioxidants have the ability to reverse the initial formation of the free radical and return the fat to its original condition which is resistant to reacting directly with oxygen. Once oxidation gets underway, however, it continues like a chain reaction and increases at an ever increasing rate. This is why it is so important to have the antioxidant present at an early stage in processing.

When oxidation occurs with flavorings, it destroys their original character and they lose freshness. When coloring agents such as carotene are involved, the chemical structure responsible for color is destroyed and they fade or, at high levels of oxidation, actually bleach out.

The antioxidants BHA and BHT are widely used in practically all fat containing foods except meats. They are normally added as a combination at a total level of 0.02 percent based on the fat content. As individual antioxidants, they can be used at levels of only 0.01 percent. They should be dissolved directly in the fat or oil portion of the food to be effective. Antioxidants are also employed in dry cereals and potato flakes and other dry mixes to prevent fat oxidation. They are almost universally found in beverages, candies and chewing gum to preserve flavor freshness. BHA and BHT are synergistic with citric acid.

SEQUESTERING AGENTS

Antioxidants usually function best in the presence of sequestering or chelating agents which inactivate the metal ions which promote the initial stages of oxidation. Sequestrants act by complexing with the metal and forming a ring structure around the metal ion. The reactive sites of the ion are thus blocked, and it cannot enter into its usual reaction.

The common sequestrants used in food are given in the following table:

SEQUESTERING AGENTS
Ethylene Diamine Tetraacetic Acid (EDTA) and its Ca and Na salts
Lecithin
Citric acid and citrates
Phosphoric acid and phosphates
Tartaric acid

The ability of these chemicals to inactivate trace metals also has use in those cases where metals react directly with certain components in the food to produce off-colors. This is the case in the greying of potatoes (iron), the greenish-gray discoloration in canned corn (copper, iron, and chromium), the surface darkening of yams and cauliflower (iron), and the pinking of canned pears (copper, iron, zinc). Sequestrants can retard all of these reactions. Without sequestrants, kidney beans turn dark red during canned storage. Unfortunately, we have not as yet found the additive which will prevent the discoloration of canned green vegetables such as peas.

Another interesting application of sequestering agents is the use of EDTA or polyphosphates to prevent the formation of the glass-like struvite crystals in canned lobster, shrimp, and crabmeat by complexing out magnesium. The discoloration of fresh and canned shellfish can also be prevented with EDTA.

CHELATING (SEQUESTERING) AGENTS

Basic Concepts

Trace metals occur naturally in all food products and are present in varying amounts in processing water, depending on the source of supply. Chelating agents, also called sequestering agents, have the ability to bind unwanted trace metals in an extremely stable metal chelate structure. Certain problems, particularly discoloration and off-flavors, caused by the presence of certain metal ions in trace quantities may be eliminated by addition of a chelating agent. Table 1 shows the basic chelation reaction.

Table 1. Chelation is an equilibrium process.

The extent to which complex formation occurs may be expressed by the equilibrium constant K for the reaction: $M + L \leftrightharpoons ML$

where $K = \frac{[ML]}{[M]\,[L]}$

M = metal ion

ML = metal-EDTA complex

Note: Expressions in brackets indicate molar concentrations.

The equilibrium constant K (also called stability constant) defines the ratio of chelated to unchelated metal in the system. Expressed in another way, it is an index of the affinity of ethylene di-amino tetra-acetic acid (EDTA) for a specific metal ion. A high K value means a low value for metal ion concentration and vice versa. EDTA and its sodium and calcium salts are highly effective chelating agents.

Since K is almost always a large number, it is usually expressed as log K (to the base 10). Table 2 lists the log K values for the nine metallic ions most encountered in food products, and the amounts of Na_2EDTA and $CaNa_2EDTA$ required to chelate these materials.

Stability constants are of considerable practical importance in attacking chelation problems for they indicate which metal ions will be chelated preferentially when EDTA is added to a solution of metal salts. Thus, in a system containing ferric, cupric and zinc ions, the iron, which has the highest stability constant (log K = 25.7), will be chelated first, then the copper (log K = 18.8), and finally, if there is enough EDTA, the zinc (log K = 16.5). The calcium in food grade $Na_2CaEDTA$ will be displaced in any system by all metal ions in Table 2, except magnesium. Na_2EDTA food grade should be used in systems to control calcium and magnesium.

There are many environmental factors affecting chelation, including pH, temperature, influence of other ions, and electrolyte content. From a practical standpoint, pH is the most important parameter to be considered. The most common interfering metal ions occurring in food products are iron and copper. Both forms of food grade EDTA effectively chelate copper and ferrous ions in the pH range of 2-12. The ferric complex of EDTA is extremely stable at pH's below 7, but above pH 8, the precipitation of ferric hydroxide begins to occur. Below pH 2, free EDTA is formed, which will lead to the breaking of the metal complex.

Table 2. Stability constants of metal-EDTA complexes.

		g chelating agent	per g metal ion
Metal	Log K	Na_2EDTA[a]	$Na_2CaEDTA$[a]
Fe^{+++}	25.7	6.6	7.3
Cu^{++}	18.8	5.8	6.4
Ni^{++}	18.56	6.3	7.0
Zn^{++}	16.5	5.7	6.3
Co^{++}	16.21	6.3	7.0
Fe^{++}	14.3	6.6	7.3
Mn^{++}	13.56	6.8	7.5
Ca^{++}	10.70	9.3	–
Mg^{++}	8.69	15.3	–

[a]Food grade

From: Bejerrum, J., Schwarzenbach, G., and Sillen, L. G. 1957. Stability Constants of Metal-Ion Complexes, with Solubility Products of Biorganic Substances. I. Organic Ligands. Chem. Soc. Burlington House, London.

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Sillen, L. G. and Martell, A. E. 1964. Stability Constants of Metal-Ion Complexes. Special Publication No. 17, The Chemical Society, Burlington House, W I London.

Applications

Food grade Na_2EDTA and $Na_2CaEDTA$ can be generally described as controls for two types of unwanted reactions in food and beverages:

(1) Control of reactions of trace metals with other organic and inorganic components in foods, which result in deterioration of color, texture, and development of precipitates. Examples of these types of reactions are the problems with end stem graying of potatoes during processing, the darkening of canned legumes during retorting and storage, and struvite formation in canned crab meat and shrimp. In wines and juices, cloudiness or haziness can occur which has been attributed to the reaction of trace amounts of copper and iron with organic substances such as tannins and pectins.

(2) Control of pro-oxidant effects of trace metals which cause the development of off-flavor and rancidity of oxidation-sensitive food. Fats and oils, milk products, salad dressings, etc., are particularly vulnerable to oxidative effects, and deterioration is accelerated by as little as 0.5 - 1.0 ppm copper or iron.

Food grade Na_2EDTA and $Na_2CaEDTA$ are accepted by the FDA for a number of canned legumes including chick, pinto and kidney beans, dry limas, and black-eye peas to promote color retention on processing and storage. Usually, the additive is dissolved in water and added to the beans by way of the brine, but salt tablets containing pre-weighed amounts of Na_2EDTA or $CaNa_2EDTA$ are also available. EDTA can also be introduced when the dry beans are reconstituted. The additive level used in the soaking solution is usually 0.3-0.5%. EDTA should also be effective in promoting color retention of other legumes such as red beans, Great Northern, Michigan pea beans, etc. Canned, whole kernel and cream style corn are subject to a gray discoloration in the presence of trace amounts of copper and chromium. The addition of 100-200 ppm calcium disodium EDTA to the brine has been effective in minimizing this discoloration. The surface darkening of sweet potatoes, yams, eggplant, peas, cauliflower, asparagus and turnips is inhibited by EDTA. Fresh pineapple chunks treated with food grade $Na_2CaEDTA$ showed improved retention of flavor.

Disodium EDTA, in conjunction with citric acid and antioxidants, has been found to preserve the color and flavor of fresh or frozen fruits during processing. Bananas, strawberries, cherries and cranberries are especially prone to discoloration. Food grade Na_2EDTA is FDA-accepted in strawberry pie filling and in freeze-dried bananas that are added to ready-to-eat cereals.Combinations of EDTA with antioxidants (e.g. BHA) are recommended for stabilizing oil of anise bergamot, lemon, lavender, peppermint, and rosemary against oxidation. The discoloration of canned mushrooms can be minimized by the addition of $Na_2CaEDTA$ to the brine prior to retorting. Levels up to 200 ppm of food grade $Na_2CaEDTA$ are also available for this application. EDTA inhibits the storage discoloration (browning) of freeze-dried vegetables such as kohlrabi; the discoloring is actually intensified by ascorbic acid.

Food grade $Na_2CaEDTA$ is accepted for use in both pickled cucumbers and cabbage to promote color, flavor, and texture retention. Trace amounts of copper and iron, which occur naturally in cucumbers and are present in brine, vinegar, etc., can adversely affect color and flavor during the long term fermentation and subsequent processing. Food grade $Na_2CaEDTA$ is favored for natural dills, sweet pickles, relishes, and other processed pickle products. The additive may be incorporated into the brine stock solution or later when packaged. Fresh packed pickles are also benefited by $CaNa_2EDTA$, particularly in flavor retention after the jars are opened and refrigerator stored.

EDTA has been found highly effective in preventing end-stem graying of white potatoes upon heat processing. Addition of 0.1% food grade Na_2EDTA to the blanching bath will minimize the after-cooking gray discoloration of frozen french fries or sliced potatoes. For best results, it is suggested that the blanching bath be maintained at less than pH 5.5 with alum. The pick-up of disodium EDTA in the potato by this technique is less than 100 ppm, which is the maximum tolerance level permitted by the FDA. Food grade $Na_2CaEDTA$ is accepted for use in canned whole potatoes to minimize darkening during retorting;up to 110 ppm of the additive is permitted. The EDTA can be added in aqueous solution to the brine or it may be added by commercially available salt tablets containing preweighed amounts of the additive. Prepared raw potatoes, washed in bisulfite and packed in polythylene bags, show a 20% increase in shelf life and resistance to mold attack when 1% disodium EDTA is added to the wash solution. Treatment with EDTA does not alter the flavor or texture of potato products.

Greening of potato tubers under fluorescent lights is reduced by spraying with EDTA. Potato salads with improved keeping qualities are prepared with EDTA and sorbic acid or benzoic acid; the use of food grade $Na_2CaEDTA$ for this purpose is permitted.

ACIDULANTS

Acidulants are employed, both directly and indirectly, for more than two dozen separate purposes in food procesing. One of their major functions as food additives is to enhance and to modify the flavor of the products. In this way, the food is rendered more palatable so that consumers are attracted to it.

Equally important is the ability of food acids to aid in the preservation of foods and in simplifying certain processing operations. Besides this, acidulants serve other specific functions, such as gelling agents for pectin, as source of acidity in leavening and as catalysts for inducing inversion of sucrose.

Flavor Modifications

All acidulants when added to a food impart a degree of tartness, which if not excessive can add a subtle character to the overall flavor of the product. The amount of food acid added depends not only upon the type of food, but also upon the background and average preferences of the persons comprising a particular consumer market. Often a food is very popular in one area but fails to be sold in another, due to the habits and certain differences between two groups of the population. It is one of the functions of a good processor to determine what differences exist in this respect and to modify his product so as to satisfy most population variations. This does not mean that new taste sensations and food combinations cannot be introduced into various areas, but that dominant flavor preferences should be carefully considered in creating additional markets and in selecting the proper areas for establishing new products.

Acidulants also have the ability to intensify the taste of certain flavoring agents which may be either present in a food or added to it. Some accidulants have blending properties which produce uniform taste effects from unrelated flavoring agents. The intensity and duration of the acid taste vary from one acidulant to another. Undesirable aftertastes can often be masked by adding an acid which prolongs the tartness sensation and extends the other flavoring effects, as will be pointed out in the pages to follow. Some acidulants appear to have actual flavor fixative properties and to enhance the aroma. Some are used primarily for seasoning purposes as in salad dressings and sauces.

Many of the properties of food acidulants as far as flavor is concerned are due to the hydrogen ions obtained upon dissociation in solution. Of equal importance is the extent of undissociation and the effect of the anions which contribute to modifying the flavor of the food and in their other uses. For this reason, many acidulants are equivalent in overall properties, but each may excel in some individual desired flavor characteristic.

Aiding Preservation

Shorter times can generally be employed for the sterilization of foods when acidulants are added, since the resistance of bacteria to heat is less the lower the pH. Organic acids show this effect at much higher pH than do inorganic acids, which would indicate that the undissociated acid as well as possibly the anions have an important role in killing of the organisms at elevated temperatures.

Several natural products such as tomatoes and various fruits normally contain large amounts of acids. Additional amounts of food acidulants may be required in canning, for proper sterilization, especially if seasonal and weather conditions or the variety used leads to a lower-than-usual acid content. The addition of food acids, however, is only an aid to proper heat-processing. It does not overcome difficulties arising from improper washing of raw produce, poor sterilization or poor sanitary conditions.

Acidulants also act as synergists to the antioxidants added to foods to prevent rancidity and other deleterious reactions. As aids in the prevention of oxidation, acidulants serve several functions. Many of them are capable of forming complexes with copper and iron salts, thereby often reducing the ability of these impurities to act as catalysts. They also supply a desired reducing environment of hydrogen ions, which can serve to partially regenerate certain antioxidants which are oxidized by reversible reactions. In the case of ascorbic acid (Vitamic C), this may mean preserving part of the vitamin content of the food. The ability of acids to form chelates and to reduce oxidation has an effect on stabilizing color and reducing turbidity in clarified liquids such as fruit juices.

Food acidulants can have an inhibiting effect on enzymatic browning by reducing the pH below the range of maximum activity of specific enzymes.

Other Functions

Wide use is also made of acidulants for many special applications, in addition to those previously described. Besides acting as gelling, leavening and inversion agents, food acids are capable of reacting with proteins in modifying the properties of baked goods and other products. They can be used as nutrients in certain fermentations such as the production of sourdough or be employed to eliminate this acid-producing step entirely.

They yield edible flavoring agents, antiheat-spattering agents and emulsifying agents, when combined with mono- or polyhydric alcohols or monoglycerides. Certain of their salts are used as stabilizers and as materials for modifying the texture of foods like cheese and various spreads. Acid salts and some of the acids themselves serve as buffers in numerous food products. They also modify melt consistency in the manufacture of products like candy, lozenges and cheese. They are the source of the necessary acidity to maintain the pink color of meat and to yield benzoic acid, the active preservative, from benzoate of soda.

Malic Acid

Malic acid may be looked upon as a general-purpose food acidulant. It is now one of the most widely used acidulants in the entire food field.

Malic acid has a high solubility, smooth tart taste and unusual taste-blending and flavor-fixative qualities. Several of its physical properties closely resemble those of citric acid which might be expected from the similarity in chemical structures. Malic acid, however, differs from other food acids in its effect on taste sensations. It has a stronger apparent acidic taste than citric acid in water and in aqueous solutions containing other taste stimulating materials.

Malic acid does not show the same rapid build-up in acidic taste when taken into the mouth as do other acidulants. Hence, it has the advantage of eliminating the sensation of a sudden "burst" in flavor often encountered with other acids. It also has excellent antibrowning properties towards fruits and other foods.

Both its powdered and granular forms are easy to handle. Under most conditions, it remains free-flowing. Even when lumping occurs under extreme conditions, the agglomerates can be readily broken up due to their low cohesion.

Fumaric Acid

Fumaric acid is the most economical of the solid food acids both from the standpoint of cost and the quantities required. Its applications, however, are limited to some extent by its relatively low solubility in water at different temperatures.

It is one of the most acidic of the solid acids, both in the amount of hydrogen ions it gives to aqueous solutions and in the apparent acidic taste which it imparts. As little as 60 per cent need be substituted for standard amounts of acidulants in common formulations. Acid costs can be reduced as much as 50 per cent in this way when its solubility permits such a substitution.

It increases the gel strength of gelatins and acts as a calcium ion liberator when incorporated in alginate preparations. It blends readily with other food acidulants and does not give a "burst" of acidic taste. Although fumaric acid does not apparently have exceptional flavor-blending characteristics, it shows an affinity for certain flavoring agents like those in grapes by producing an aftertaste which serves to supplement the overall flavor.

Adipic Acid

This saturated dicarboxylic acid has found increasing use in foods during the last fifteen years. It gives excellent gelatin sets to food powders and is practically nonhygroscopic. Its solubility is from four to five times that of fumaric acid at room temperatures.

It gives a smooth, mild tart taste. Thus, it is used in products having delicate flavors without imparting an undesirable tang. With grape flavors, it yields a lingering supplementary flavor.

Its aqueous solutions have the lowest acidity of any of the common food acids. For concentrations from 0.5 to 2.4 grams per 100 milliliters, the pH of its solutions varies less than half a unit. Hence, it can be used as a buffering agent to maintain acidities within a pH range of 2.5 to 3.0. This is highly desirable in many food products. The pH of its solutions is low enough, however, to inhibit the browning of fruits and other foods.

Succinic Acid

Succinic acid is one of the newer nonhygroscopic acidulants of relatively low acid strength. Its apparent taste characteristics are very similar to the other acidulants of this type. There is some evidence that it has a rather slow taste build-up which is an advantage when it is used as an acidulant in certain foods. It gives a much greater latitude in the formulation of powdered foods and beverages, since it has a much greater solubility in water at room temperatures than the other nondeliquescent acids.

Succinic acid is one of the natural acids found in foods, such as broccoli, rhubarb, sugar beets, fresh meat extracts, various cheeses and sauerkraut. All of these products have very distinct and marked flavors which may in part be due to a flavor enhancement by the small amounts of succinic acid naturally present. This would suggest that succinic acid might have some interesting effects on various flavors which could not be duplicated with other food acids.

Citric Acid

Citric acid occurs abundantly as a natural acid in citrus fruits, tomatoes, and in numerous other fruits and vegetables. This is the most widely used acid in processed foods. Its major advantages as an acidulant are its high solubility in water, the appealing effects on food flavor, and its potent metal-chelating action. Citric acid has been used in foods in the U. S. for over 100 years.

Both citric acid and its salts are allowed in various fruit juice drinks and diluted juice beverages. The acid may be employed in preparing mayonnaise and salad dressings. Citric acid and sodium citrate may be used in fruit butters, fruit jellies, and in preserves. The acid is used both to control the pH for optimum gel formation and as a flavoring agent.

Canned vegetables, with the exception of those specifically regulated, may contain citric acid as an acidulant. Examples are artichoke hearts and tomatoes. The acid is also an optional ingredient in canning of prune juice and figs.

Citric acid is extensively employed in the preparation of carbonated beverages to bring out the flavor and impart a "tang" to many of the beverages. It chelates trace metals which may cause haze or deterioration of color or flavor. It is also employed to adjust the acidity of relishes, sauces, and other food products requiring flavor enhancement. In the canning of crab meat, lobster meat, scallops, and oysters, citric acid is used to inhibit discoloration and the development of off-flavors and odors.

Phosphoric Acid

Phosphoric acid is an inorganic acid and the strongest acid used as a food acidulant, giving the lowest pH. It is one of the most important acidulants and the least costly of all the acids used in food products. The combination of low cost, high water solubility, and pH reducing characteristics make phosphoric acid very attractive as a food acidulant in products where its use also offers flavor compatibility. This acid is most extensively used in carbonated beverages. It is also used in cheeses and in brewing to adjust the pH, to neutralize caustic soda in peeling of fruit, and to a small extent in the manufacture of jams and jellies.

Acid phosphates, such as monocalcium and dicalcium phosphates and sodium acid pyrophosphate are ingredients in baking powders. Calcium, magnesium, potassium, or sodium phosphates are employed as buffering agents. Sodium, disodium, and trisodium phosphates are used in artificially sweetened fruit jellies. Various sodium phosphates increase the water-holding capacity of meat. Some of the phosphates are used as chelating agents, such as calcium and sodium hexametaphosphates, sodium pyrophosphate, and tetrasodium pyrophosphate.

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GLOSSARY OF TERMS

ABSOLUTE HUMIDITY. Actual weight of water vapor contained in a unit volume or weight of air. See also RELATIVE HUMIDITY.

ACID FOODS. Any foods with a finished equilibrium pH value of 4.6 or smaller. Tomatoes, pears, pineapples, and the juices thereof, having a pH of less than 4.7, and figs having a pH of 4.9 or below are also classed as acid foods.

ACID NUMBER. Number of KOH required to neutralize the free fatty acids in 1 g of fat, wax, or resin.

ACIDURIC. Microorganisms that can grow in high acid foods, i.e., with a pH value below 3.0. Generally are of low heat resistance.

ACTIVATED SLUDGE. Sludge floc produced in raw or settled wastewater bv the growth of bacteria and other organisms in the presence of dissolved oxygen.

ACTIVATED SLUDGE PROCESS. A biological wastewater treatment process in which a mixture of wastewater and activated sludge is agitated and aerated.

ADDITIVE. Any substance, the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food.

ADSORBENT. Material on whose surface adsorption takes place.

ADSORPTION. Adhesion of a substance to the surface of a solid or liquid.

ADULTERANT (ADULTERATION). Foreign material in food, especially substances which are esthetically objectionable, hazardous to health, or which indicate that unsanitary handling or manufacturing practices have been employed.

AERATION. The bringing about of intimate contact between air and a liquid by bubbling air through the liquid or by agitation of the liquid to promote surface absorption of air.

AERATION TANK. A tank in which sludge, sewage, or other liquid waste is aerated.

AEROBES. Micro-organisms that need oxygen for growth. Obligate aerobes cannot survive in the absence of oxygen.

AEROBIC. Living or active only in the presence of free oxygen.

AERATOR. A device used to promote aeration.

AEROSOL. Colloidal suspension in which gas is the dispersant. Dispersion or suspension of extremely fine particles of liquid or solid in a gaseous medium.

AGAR. Dried, purified stems of a seaweed. Partly soluble and swells with water to form a gel. Used in soups, jellies, ice-cream, meat and fish pastes, in bacteriological media, as a stabilizer for emulsions. Also called agar-agar.

AGING. See MATURATION.

AGING. Treatment of flour with oxidizing agents.

AIR FLOTATION. Synonymous with flotation.

AJINOMOTO. See GLUTAMATE, SODIUM.

ALBEDO. The white inner layer of citrus fruid peel. Consists of sugars, cellulose and pectins; used as a source of pectin for commercial manufacture.

ALGAE. Major group of lower plants, single and multi-celled, usually aquatic and capable of synthesizing their foodstuff by photosynthesis.

ALGINATES. Salts of alginic acid found in many seaweeds. Used as thickeners and stabilizers in ice-cream and synthetic cream, in artificial cherries, and as alginate sausage casings.

ALLSPICE (or Jamaica pepper). Dried fruits of the evergreen *Pimenta officinalis,* also known as pimento.

ALMOND, BITTER. Ripe seed of *Prunus amygdalus* var. amars (almond tree).

ALMOND, SWEET. Ripe seeds of *Prunus amygdalus* var. dulcis.

AMINO ACID. Proteins are composed of about 23 amino acids. Eight of them must be provided in the human diet, the essential amino acids. The remaining 15 can be synthesized in the body. Many amino acids are manufactured synthetically, and, lysine and methionine in particular, can be added to food and feeds to increase their nutritive value.

ANAEROBES. Micro-organisms that grow in the absence of oxygen. Obligate anaerobes cannot survive in the presence of oxygen. Facultative anaerobes normally grow in oxygen but can also grow in its absence.

ANAEROBIC. Living or active in the absence of free oxygen.

ANION. Negatively charged ion such as hydroxide (OH^-), carbonate ($CO_3^=$), phosphate ($PO_4^=$).

ANIONIC SURFACTANTS. Ionic surface-active agents in which the portion that associates with the internal phase is the anion; they include carboxylic acids, sulfuric acid esters, and sulfonic acids.

ANTHOCYANINS. Violet, red, and blue coloring matter of many fruits, flowers, and leaves. Depolarizers in electrochemical reactions; as such they cause trouble in canned foods by accelerating internal can corrosion.

ANTIBIOTIC. A substance that inhibits the growth of microorganisms usually produced by other organisms such as penicillin.

ANTIFOAMER. Liquid of low intrinsic surface tension that prevents formation of a foam.

ANTIMICROBIAL. A compound which inhibits the growth of a microbe.

ANTIMYCOTIC AGENT. A substance which destroys or inhibits the growth of molds and other fungi.

ANTIOXIDANTS. Substances that retard the oxidative rancidity of fats, or the oxidation of other substances.

ANTISEPTIC. A substance that prevents or inhibits the growth of microorganisms on animate surfaces, such as skin.

APPARENT VISCOSITY. See VISCOSITY. Viscosity of a complex (non-Newtonian) fluid under given conditions.

ASEPSIS. Clean and free of microorganisms.

ASEPTIC PROCESSING AND PACKAGING. The filling of a commercially sterilized cooled product into presterilized containers, followed by aseptic hermetical sealing, with a presterilized closure, in an atmosphere free of microorganisms.

AUTOCLAVE. A vessel in which high temperatures can be reached by using high steam pressure. Bacteria are destroyed more readily at elevated temperatures, and autoclaves are used to sterilize food, for example in cans.

BACILLUS. A rod-shaped bacterium, varying in thickness from 1/100,000th to 1/10,000th of an inch, and in length from 1/25,000th to 1/1,000th of an inch. Some bacillus produce spores.

BACTERICIDE. Any substance that destroys bacteria, although not necessarily the spores of bacteria.

BACTERIOSTATIC. Preventing the growth of bacteria without killing them.

BAFFLE. Partition or plate that changes the direction or restricts the cross section of a fluid, thus increasing velocity or turbulence.

BARRIER, GREASE-RESISTANT. A material that prevents or retards the transmission of grease or oils.

BARRIER, WATER-RESISTANT. A material that retards the transmission of liquid water.

BARRIER, WATER-VAPOR-RESISTANT. A material that retards the transmission of water vapor.

BASE BOX. A unit of area of tin plate equivalent to 31,360 sq. in. The term "90#plate" means tin plate of such thickness that the above area weighs 90 lbs., considering commercial tolerances.

BASE PLATE PRESSURE. The force of the base plate holding the can body and end against the chuck during the seaming operation. In general, has the following effect on the seaming formation:

Low pressure–short body hook
High pressure–long body hook

BAUME. The name of one of the many hydrometer scales used for determining the relative density of liquids as compared to a standard liquid. There are two Baume scales. One for liquids lighter than water, the other for liquids heavier than water.

BEAD. A rounded depression around the surface of a container or end; used to stiffen or improve its appearance.

BEADED CAN. See also BEAD. A can reinforced by bead indentations in the body.

BENTONITE. A colloidal clay used as an absorbent. Also used in model systems for determining rate of heat penetration.

BIODEGRADABILITY. Susceptibility of a chemical compound to depolymerization by the action of biological agents.

BIOLOGICAL OXIDATION. The process whereby, through the activity of living organisms in an aerobic environment, organic matter is converted to more biologically stable matter.

BIOLOGICAL OXYGEN DEMAND (B.O.D.). Microorganisms consume oxygen for their respiration, and the uptake of oxygen by a contaminated material, e.g., sewage, water, etc., is a measure of microbial activity. Also termed biochemical oxygen demand.

BLACK PLATE. Low carbon steel plate base for tin mill products, like tin plate.

BLANCHING. Heating by direct contact with hot water or live steam. It softens the tissues, eliminates air from the tissues, destroys enzymes, washes away raw flavors.

BLEEDERS. Openings used to remove air that enters with steam, from retorts and steam chambers and to promote circulation of steam in such retorts and steam chambers. Bleeders may serve as a means of removing condensate.

B.O.D. See BIOLOGICAL OXYGEN DEMAND.

BODY. Principal part of a container, usually the largest part in one piece containing the sides. May be round, or cylindrical, or other shape.

BODY HOOK. That flange portion of the can body that is turned back for the formation of the double seam.

BODY MAKER. A machine for automatic forming of a cylindrical metal can or drum body from a body blank. In the manufacture of tin cans the body maker may also automatically solder the side seam.

BOTTOM SEAM. Also known as factory end seam. The double seam of the can end put on by the can manufacturer.

BOTULISM. Food poisoning due to the toxin produced by *Clostridium botulinum.*

BREAK-POINT CHLORINATION. Addition of chlorine to water beyond the point where chloramines are oxidized, and where further increases in the dosage of chlorine will result in a proportional increase of chlorine residual.

BRINE. Salt, sugar and water mixture in which most vegetables are canned. Water is not chlorinated.

BRINES. Salt solutions used in canning and pickling.

BRITISH THERMAL UNIT, BTU. The British engineering unit of heat quantity. It is approximately the quantity of heat which will raise the temperature of 1 lb. of water 1°F. BTU = 0.252 Cal. = 1054 joules.

BRIX. The measure of density of a solution, more particularly a solution containing sucrose, as determined by a hydrometer. Degrees Brix equal percent sucrose in water solution at 20°C (68°F).

BRIX HYDROMETER. Hydrometer graduated in percentage sugar at 20°C (68°F).

BROWNING REACTION. A reaction in foods, usually deteriorative, involving amino (e.g., from amino acids or proteins) and carbonyl (e.g., from glucose) groups; this reaction often leads to a brown discoloration and sometimes to off-flavors and changes in texture.

BTU. See BRITISH THERMAL UNIT.

BUCKLING (OF CANS). Cans becoming permanently distorted along the double seam; caused by excessive internal pressure.

BUFFER. Any substance in a fluid which tends to resist the change in pH (hydrogen-ion concentration) when acid or alkali is added.

BULK DENSITY. Weight per unit volume of a quantity of solid particles; depends on packing density.

BURSTING STRENGTH. The strength of material in pounds per square inch, measured by the Cady or Mullen tester.

CALENDERING. Subjecting a material to pressure between two or more counter-rotating rollers.

CALIPER. Thickness as related to paperboard, of a sheet measured under specified procedures expressed in thousandths of an inch. Thousandths of an inch are sometimes termed "points". The precision instrument used in the paperboard industry to measure thickness. To measure with a caliper.

CALORIE. Unit of heat; the amount of heat necessary to raise the temperature of a gram of water 1°C. Nutritionists use the large Calorie or kilo-Calorie (spelled with capital C), which is 1,000 calories. One Calorie (kilo-Calorie)=4184 joules or 3.968 BTU.

CAN, CYLINDER. A can whose height is relatively large compared to its diameter. Generally called a tall can.

CAN, FLAT. A can whose height is equal to or smaller than its diameter.

CAN, KEY-OPENING. A can opened by tearing off a scored strip of metal around the body by means of a key, or any can opened by means of a key.

CAN, SANITARY. Full open top can with double seamed bottom. Cover double seamed on by packer. Ends are gasket or compound lined. Used for products which are process packed. Also known as a "Packer's Can".

CAP. See also CLOSURE. Any form or device used to seal off the opening of the container, so as to prevent loss of its contents.

CAP, LUG. A cap closure for glass containers in which impressions in the side of the cap engage appropriately formed members on the neck finish to provide a grip when the cap is given a quarter turn, as compared to the full turn necessary with a screw cap.

CAP, SCREW. A cylindrical closure having a thread on the internal surface of the cylinder capable of engaging a comparable external thread on the finish or neck of a container, such as glass bottle, collapsible tube, etc.

CAP, SNAP-ON. A type of closure for rigid containers. The sealing action of a snap-on cap is effected by a gasket in the top of the cap that is held to the neck or spout of the container by means of a friction fit on a circumferential bead. Material of construction is either metal or semi-rigid plastic.

CAP, TWO-PIECE VACUUM (TWO-PIECE VACUUM CAP). Standard C-T (continuous thread) or D-S (deep screw) caps, equipped with a separate disk or lid which is lined with sealing for vacuum-packing processes.

CASE. A non-specific term for a shipping container. In domestic commerce, "case" usually refers to a box made from corrugated or solid fiber board. In maritime or export usage, "case" refers to a wooden or metal box.

CATALYST. Substance that alters the rate of chemical change and remains unchanged at the end of a reaction.

CATION. Positively charged ion such as K^+, NH_4^+.

CATIONIC SURFACTANTS. Ionic surface-active agents in which the portion that associates with the internal phase is the cation. They include simple amine salts, quaternary ammonium salts, amino imides and imidazolines. Cationic surfactants often have germicidal, anticorrosive, and antistatic properties.

CELSIUS (°C). Temperature on a scale of 100° between the freezing point (0°) and the boiling point (100°) of water.

CENTIPOISE (cP). Unit of viscosity equal to 1/100 dyne/sec²/cm².

CHLORINATION. Building-up the chlorine content (as hypochlorous acid) to process or sanitize water supplies. See also IN-PLANT CHLORINATION and BREAK-POINT CHLORINATION.

CHUCK. Part of a closing machine which fits inside countersink and in chuck ring of can lid or end during seaming operation.

CINNAMON. Barks of various species of the genus Cinnamomum; split off shoots, cured and dried.

CLOSING MACHINE. Also known as a double seamer. Machine which double seams can end onto can bodies.

CLOSTRIDIA. Genus of spore forming bacteria. *Clostridium botulinum* is the most heat-resistant of the food-poisoning organisms; its growth is inhibited at pH 4.6 and below, thus it is only a problem in low-acid foods. Produces an endotoxin, botulina, highly toxic in minute doses but destroyed by heat. Destruction of this organism is generally accepted as the minimum standard of processing for low-acid and medium-acid canned food, although other Clostridia are more heat-resistant.

CLOSURE. The joint or seal which is made in attaching the cover to a glass container. Also, the type of closure, such as friction, lug, screw top, etc.

Cm. CENTIMETER. Equivalent to 0.394 in.

COAGULANT. A material, which, when added to liquid wastes or water, creates a reaction which forms insoluble floc particles that absorb and precipate colloidal and suspended solids.

COCCUS. Type of bacteria. Plural "cocci." A round cell, varying in diameter from 1/100,000th to 1/10,000th of an inch. There are various additions to this word, such as "staphylococci", meaning cocci occurring in groups, like bunches of grapes, and "streptococci" or cocci occurring in more or less long chains. Cocci do not produce spores. Certain streptococci and staphylococci cause food poisoning in fresh foods.

COCKED BASE PLATE. A base plate on a double seamer which is not parallel to seaming chuck. This results in a top double seam having a body hook uneven in length.

COCKED BODY. A can body which is not a perfect cylinder, i.e. open ends of cylinder not at right angles to body. This defect results in body hooks of uneven length at both ends. Where the body is long on one end, it will be short on the other end.

COD (CHEMICAL OXYGEN DEMAND). An indirect measure of the biochemical load exerted on the oxygen assets of a body of water when organic wastes are introduced into the water. It is determined by the amount of potassium dichromate consumed in a boiling mixture of chromic and sulfuric acids. The amount of oxidizable organic matter is proportional to the potassium dichromate consumed. Where the wastes contain only readily available organic bacterial food and no toxic matter, the COD values can be correlated with BOD values obtained from the same wastes.

CODE, CAN. Canner's identification stamped in relief on canner's end. Also, can maker's identification stamped in relief on manufacturer's end.

COKE TIN PLATE. See TIN PLATE, COKE.

COLIFORM BACTERIA. Group of aerobic bacteria of which *Escherichia coli* is the most important member. Many coliforms are not harmful, but as they arise from feces they are useful as a test of contamination, particularly as a test for water pollution.

COLLOID. Fine particles (the disperse phase) suspended in a second medium (the dispersion medium; can be solid, liquid, or gas, suspended in solid, liquid, or gas).

COLLOIDAL SUSPENSION. Two-phase system having small dispersed particles suspended in a dispersant.

COLONY. A microscopically visible growth of microorganisms on a solid culture medium.

COMMERCIAL STERILITY (OF FOOD). The condition achieved by application of heat which renders such food free of viable forms of microorganisms having public health significance, as well as any microorganisms of non-health significance capable of reproducing in the food under normal non-refrigerated conditions of storage and distribution. "Commercial sterility" of equipments and containers used for aseptic processing and packaging of food means the condition achieved by application of heat, chemical sterilant(s), or other appropriate treatment which renders such equipment and containers free of viable forms of microorganisms having public health significance as well as any microorganisms of nonhealth significance capable of reproducing in the food under normal nonrefrigerated conditions of storage and distribution.

COMING-UP-TIME. The time which elapses between the introduction of steam into the closed retort and the time when the retort reaches the required processing temperature.

COMPOUND (IN CANS). A sealing material consisting of a water or solvent emulsion or solution of rubber, either latex or synthetic rubber, placed in the curl of the can end. During seaming operation, the compound fills the spaces in the double seams, sealing them against leakage and thus effecting a hermetic seal.

CONSISTENCY. Resistance of a fluid to deformation. For sample (Newtonian) fluids the consistency is identical with viscosity, for complex (non-Newtonian) fluids, identical with apparent viscosity.

CONTAMINATION. Entry of undesirable organisms into some material or container.

CONTINUOUS PHASE. External phase of an emulsion.

CONTINUOUS THREAD. An uninterrupted protruding helix on the neck of a container to hold screw-type closure.

CONVECTION. Natural or forced motion in a fluid induced by heat or the action of gravity.

COOLING. (a) In a freezing plant, the process of pre-cooling produce prior to placing it in quick-freezing chamber. (b) The process of cooling heated cans immediately after processing. Cans may be stationary or moving. In various methods, cans are immersed, partially covered or spray cooled.

COUNTERSINK DEPTH. The measurement from the top edge of the double seam to the end panel adjacent to the chuck wall.

COVER. Can end placed on can by packer. Also known as top, lid, packer's end, canner's end.
COVER HOOK. That part of double seam formed from the curl of the can end.
CROSS OVER. The portion of a double seam at the lap.
CROSS SECTION. Referring to a double seam. A section through the double seam.
CRYSTAL SIZE. Grade designated for identifying the relative crystal size of non-ferrous metals. For tin plate corrosion purposes, the lower the numerical grade the better the corrosion resistance.
C-T. Abbreviation for CONTINUOUS THREAD. Used in referring to the helical threaded neck-finish of glass containers or to closures designed for application to these finishes. C-T denotes continuity form of thread to differentiate it from the LUG, I-T, or other form of interrupted thread forms.
CULL. Product rejected because of inferior quality.
CULTURE. A population of microorganisms cultivated in a medium: *pure culture* - single kind of microorganism. *mixed culture* - two or more kinds of microorganisms growing together.
CULTURE MEDIUM. (pl.: MEDIA). Any substance or preparation suitable for and used for the growth and cultivation of microorganisms. *selective medium* - A medium composed of nutrients designed to allow only growth of a particular type of microorganism. *broth medium* - A liquid medium for growth of microorganisms. *agar medium* - Solid culture medium.
CURL. The extreme edge of cover which is bent inward after end is formed. In double seaming, the curl forms the cover hook of the double seam.
CUT CODE. A break in the metal of a can end due to improper embossing marker equipment.
CUT-OVER. Sharp bend or break in the metal at the tip of the countersink. The cut-over occurs during seaming due to excess metal being forced over top of seaming chuck. Usually caused by heavy laps. . .i.e., laps containing excessive solder, but may be due to improper adjustment of the double seaming equipment.
DEAERATION. Removal of oxygen from produce juices to prevent adverse effects on juice properties.
DENITRIFICATION. The process involving the facultative conversion by anaerobic bacteria of nitrates into nitrogen and nitrogen oxides.
DENSIMETER. Instrument for measuring the density or the specific gravity of liquids.
DETERGENT. Surface-active material or combination of surfactants designed for removal of unwanted contamination from the surface of an article.
DETERIORATION. A nonbiological, physical, or chemical change in food which adversely affects quality.
DEW POINT. The temperature at which air or other gases become saturated with vapor, causing the vapor to deposit as a liquid. The temperature at which 100% relative humidity is reached.
DEXTROSE. A widely occurring crystallizable simple sugar which contains 6 carbon atoms in contrast to 12 found in sucrose.
DICER. Equipment which cuts fruit, vegetables and other foods into small cubes.
DIFFUSION. Mixing of molecules or atoms by random molecular or atomic motion.
DIGESTION. The biological decomposition of organic matter in sludge, resulting in partial gasification, liquefaction, and mineralization.
DILL. Dried ripe fruit of *Anethum graveolens.* Used in pickles and soups.
DISINFECTANT. An agent that frees from infection by killing the vegetative cells of microorganisms.
DISPERSION. Physical, usually temporary, mixture of two insoluble phases.
DISPOSAL. The discharge of waste water for its ultimate use.
DISSOLVING. Formation of a solution by dispersion of one material (solute) at a molecular (or less) level in another material (solvent).
DOMED. A curved profile container end used for strength or appearance.
DOUBLE SEAM. To attach an end to a can body by a method in which five (5) thicknesses of plate are interlocked or folded and pressed firmly together. A joint formed by interlocking the edges of both the end and body of a can.
DOUBLE SEAMED END. Part of a can which is attached to the body of a double seamed can to form the top or the bottom.
DROOP. Smooth projection of a double seam below bottom of normal seam. Usually occurs at the side seam lap.
DROP TEST. A test for measuring the properties of a container by subjecting the packaged product to a free fall from predetermined heights onto a surface with prescribed characteristics.

EDTA. See Ethylenediamine tetra-acetic acid.
EFFLUENT. Wastewater or other liquid, partially or completely treated or untreated, flowing out of a process operation, processing plant, or treatment plant.
ELECTROPHORESIS. Migration of the electrically charged particles toward the oppositely charged electrode.
ELMENDORF TEST. A test for measuring the tearing resistance of paper, paperboard, tape, and other sheet materials.
EMBOSS (-ED), (-ING). Raised design or lettering on the surface of an object.

EMULSIFIER (EMULSION). A compound or substance which promotes and stabilizes a finely divided dispersion of oil and water.

EMULSION. System consisting of two incompletely miscible liquids, one being dispersed as finite globules in the other. A small amount of a third substance may render the dispersion stable. The liquid broken up into globules is the dispersed (discontinuous) phase; the surrounding liquid is the external (continuous) phase.

ENAMEL. A vitreous or paint-like composition used as a protective coating usually baked onto the packaging material before fabrication into the finished container. On the inner surface of metal containers its purpose is to protect either the contents or the container. On the outer surface its purpose is to prevent corrosion or to decorate.

ENDOTOXIN. A toxin produced within an organism liberated only when the organism disintegrates.

ENRICHED. A term which refers to the addition of specific nutrients to a food as established in a standard of identity and/or quality.

ENTEROTOXIN. A toxin specific for cells of the intestine. Gives rise to symptoms of food poisoning.

ENZYMATIC BROWNING. The darkening of plant tissues or products produced by enzymatic reactions.

ENZYME. A compound of biological origin which accelerates a specific chemical reaction.

EQUILIBRIUM MOISTURE CONTENT. The moisture content of a substance at which it will neither gain or lose moisture in an atmosphere having given relative humidity.

EQUILIBRIUM RELATIVE HUMIDITY. The relative humidity of the ambient atmosphere surrounding a substance when the substance neither gains or losses moisture.

ETHYLENEDIAMINE TETRA-ACETIC ACID. (EDTA). Forms stable complexes with metals, hence called sequestering agent or chelating agent. Its calcium and sodium salts are used in foods to sequester traces of metallic impurities that cause food deterioration.

EUTROPHICATION. Applies to lake or pond becoming rich in dissolved nutrients, with seasonal oxygen deficiencies.

EXHAUST. Heating of food in cans prior to closing the cans to produce a partial vacuum in containers.

EXHAUSTER. Equipment to heat food in cans prior to closing the cans, so as to produce a partial vacuum in the containers.

EXOTOXIN. A toxin excreted by a microorganism into the surrounding medium.

EXTENDED AERATION. A modification of the activated sludge process that employs aeration periods of 24 hours or more, completely mixing, and high levels of mixed liquor solids.

EXTRUSION. The compacting of a plastic material and the forcing of it through an orifice in more or less continuous fashion.

EXTRUSION. The process of forcing a material in plastic condition through an orifice.

FACTORY END. Bottom or can manufacturer's end.

FACULTATIVE BACTERIA. Bacteria which can exist and reproduce under either aerobic or anaerobic conditions.

FALSE SEAM. A small seam breakdown where the cover hook and body are not overlapped, i.e., no hooking of body and cover hooks. See also KNOCKDOWN FLANGE.

FALSE SEAM. The cover hook and body hook are not tucked in.

FATTY ACIDS, ESSENTIAL. Collective name for the three unsaturated fatty acids, linoleic, linolenic and arachidonic. They are dietary essentials.

FEATHER. Beginning of a cut-over. At the top of the container's countersink, the metal is forced over the seaming chuck forming a sharp edge that may be detected with the fingernail. Commonly referred to as "Sharp Edge".

FERMENTATION. The action of microorganisms upon foods. Anaerobic respiration. Usually fermentation is undesirable, but sometimes it is produced intentionally, such as in the manufacture of vinegar from apple cider.

FINISH. The opening of a container shaped to accommodate a specific closure.

FIRST OPERATION. The first operation in double seaming. In this operation the curl of the end is tucked under the flange of the can body which is bent down to form cover hook and body hook, respectively.

FLANGE. To flare out the top of a can body to prepare it for double seaming to an end. Also the flaring projection about the end of a can body. The outermost projection of an end, cover, or cap.

FLASH-PASTEURIZATION. Process in which the material is held at a much higher temperature than in normal pasteurization, but for a considerably shorter period.

FLAT-SOURS. Thermophilic and thermoduric bacteria, facultative anaerobes, that attack carbohydrates with the production of acids, but without gas formation. Flat-sour spoiled canned foods therefore show no swelling of the ends.

FLAVEDO. The colored outer layer of citrus fruit peel. It contains the oil sacs and fruit pigments.

FLIPPER. A can having both ends flat but with insufficient vacuum to hold the ends in place, thus a sharp blow will cause the end to become convex, but both ends may be pressed to their normal position.

FLOCCULATION. The process of forming larger masses from a large number of finer suspended particles.

FLOTATION. Removal of solids, oil, or fat from wastewater by causing the material to float to the water surface with the aid of heat or entrained air.
FLOTATION GRADER. Equipment for grading peas and lima beans in a brine solution or water.
FLUIDITY. Reciprocal of viscosity.
FLUMING. In-plant transportation of product or waste material through water conveyance.
FLUORIDATION. Process of adding traces of sodium fluoride to drinking water to arrest or prevent dental decay.
FLUX. A chemical used to aid in soldering by removing the oxides.
FOAM SEPARATION. Synonymous with flotation.
FOAMING AGENT. Surface-active material that is used specifically to form a dispersion of a gas in a liquid or solid medium.
FOOD ADDITIVE. A chemical intentionally added to food to improve some quality attribute.
FOOD INFECTION. An illness caused by an infection produced by invasion, growth and damage to the tissue of the host due to the ingestion of viable pathogenic microorganisms associated with the food.
FOOD INTOXICATION. An illness resulting from the ingestion of bacterial toxin with or without viable cells. The illness does not require actual growth of cells in the intestinal tract.
FOOD POISONING. A general term applied to all stomach or intestinal disturbances due to food contaminated with certain microorganisms or their toxins.
FORTIFIED. Food to which specific nutrients have been added. Also "enriched".
FREEZE-DRYING. A process of dehydration in which the moisture is removed by the sublimation of ice from the frozen product.
FRUCTOSE. An alternate chemical name for levulose.
FUNGICIDAL AGENT. Destroys existing fungal cells.
FUNGICIDE. Any substance that destroys fungi or inhibits the growth of spores or hypahe. Legally, sometimes the term is interpreted as also including yeasts and bacteria.
FUNGISTATIC AGENT. Prevents growth of fungi (molds) without necessarily killing the existing cells.
GAGE (GAUGE). Term used to designate the thickness of a plate.
GAS PACKING. Packaging in a gas-tight container in which any air has been replaced by a gas that contains practically no free oxygen, such as commercial carbon dioxide or nitrogen.
GASKET. In cans, a filler, usually of synthetic rubber, used in the seam for the purpose of making it hermetically tight.
G-CAP. A No. 70 (70mm) cap with abnormally deep screw. Used primarily for mayonnaise and salad dressing.
GEL. Semisolid system that consists of a solid held in a liquid; a more solid form than a sol.
GELATION. Solidifying, resulting in the formation of a gel.
GELOMETER. Instrument used to measure the time required for a fluid to gel. Also, instrument used to determine the firmness of a gel.
GERM. A microorganism; a microbe usually thought of as a pathogenic organism.
GERMICIDE. Substance that will kill all ordinary microorganisms that cause disease, but that is not necessarily capable of destroying bacterial spores.
GLUCOSE. An alternate chemical name for dextrose. A name given to corn syrups which are obtained by the action of acids and/or enzymes on corn starch.
GLUTAMATE, SODIUM. Sodium salt of glutamic acid, an amino acid. Enhances the flavor of some foods. Frequently added to soup mixes, meat products, and certain other foods.
GRADING. The selection of produce for certain purposes. Produce is sorted for size, color, quality, ripeness, etc. May be done manually or mechanically on sizing belts, flotation graders, etc. Term also applied to finished products.
GUM. Class of colloidal substances that is exuded by plants.
HALOPHILIC. Can grow or survive in a medium with a relatively high salt concentration.
HARD SWELL. Spoilage in which can ends are swelled too hard to be readily depressed by applying thumb pressure.
HEADSPACE, GROSS. The vertical distance between the level of the product (generally the liquid surface) and the inside surface of the lid in an upright rigid container (the top of the double seam of a can or the top edge of a glass jar).
HEADSPACE, NET. The vertical distance between the level of the product (generally the liquid surface) and the inside surface of the lid in an upright, rigid container having a double seam, such as a can.
HEAT EXCHANGER. Equipment for heating or cooling liquids rapidly by providing a large surface area and turbulence for the rapid and efficient transfer of heat.
HEAT, LATENT. Heat absorbed or liberated in a change of physical state such as evaporation, condensation, freezing or sublimation. Expressed as BTU per lb., kCal per kg or joules per kg.
HEAT, SENSIBLE. Heat that has gone into raising the temperature of steam without change of pressure or absolute humidity.
HEAVY LAP. A lap containing excess solder, also called a thick lap.

HEEL. The part of a container between the bottom bearing surface and the side wall.

HERMETICALLY SEALED CONTAINER. A container which is designed and intended to be secure against the entry of microorganisms and to maintain the commercial sterility of its contents after processing.

HERRINGBONE SCORE. Weakening lines made in the body of a key opening can between and at an angle to the parallel scored lines. Designed to lead a tear back into the regular score line.

HOMOGENIZATION. The process of making incompatible or immiscible components into a stabilized uniform suspension in a liquid medium.

HOMOGENIZER. Mixing machine used for the preparation of emulsions of fine particle size. The emulsion is forced at high pressure through the annular space between an adjustable valve and its seat.

HOOK, BODY. That portion of the edge of a can body which is turned back for the formation of a double seam.

HOOK COVER. That portion of an end which is turned back between the body and the body hook for the formation of an end seam.

HOOK EDGED, (SIDE SEAM). That portion of the edge of the body which is turned back for the formation of a locked side seam.

HOOK, UNEVEN. A body cover hook which is not uniform in length.

HTST PROCESS. Pasteurization or sterilization process characterized by High Temperature applied for a Short Time.

HUSKER. Equipment for stripping husks off corn.

HYDROGEN-ION CONCENTRATION. Acidity or alkalinity of a solution measured by the concentration of hydrogen ions present. Also called pH.

HYDROGEN SWELL. Swell resulting from hydrogen generated in the can as a result of a reaction of the product with the metal of the can.

HYDROLYSIS. Process of splitting a molecule into smaller parts by chemical reaction with water.

HYDROMETER DENSIMETER. Device used for the measurement of specific gravity or density.

HYDROPHILIC. Attracted to water; water soluble.

HYGROSCOPIC. Absorbs water from water vapor in atmosphere.

IMPACT STRENGTH. The ability of a material to withstand mechanical shock.

INCUBATION. Holding cultures of microorganisms under conditions favorable to their growth. Also, the holding of a sample at a specified temperature for a specified period of time before examination.

INCUBATION TIME. The time period during which microorganisms inoculated into a medium are allowed to grow.

INDICATOR. Usually refers to a pH indicator. Various dyes change color at specific degree of acidity or alkalinity and this color change is used as an indicator of pH.

INHIBITION. Prevention of growth or multiplication of microorganisms, or prevention of enzyme activity.

INITIAL TEMPERATURE (IT). The average temperature of the contents of the coldest container to be processed at the time the sterilizing cycle begins, as determined after thorough stirring or shaking of the filled and sealed container.

INOCULUM. The material containing microorganisms used for inoculation.

INOCULATE. The artificial introduction of microorganisms into a system.

IN-PLANT CHLORINATION. Chlorination beyond the break-point of water used in a food plant, usually to a residual of 5 to 7 ppm.

INSPECTION BELT. Conveyor belt where materials are visually inspected.

INTOXICATION. The adverse physiological effects on an organism of consuming a toxic material.

INVERT, OR INVERT SUGAR. The mixture of equal parts of dextrose and levulose produced by the action of acid or enzymes on solutions of sucrose.

ION. Electrically charged portion of matter of atomic or molecular dimensions.

ION EXCHANGE. A reversible chemical reaction between a solid and a liquid by means of which ions may be interchanged between the two. It is in common use in water softening and water deionizing.

IRON CHINK. Mechanical device used in salmon canning to automatically remove heads, tails, fins, and entrails.

JAM. Product made by cooking to a suitable consistency properly prepared fruit with sugar, or sugar and dextrose, with or without water. No less than 45 lbs. fruit are used to each 55 lbs. of sugar or sugar and dextrose. Sometimes pectin and/or an acid are also added.

JELLY. Fruit jelly is the semisolid, gelatinous product made by concentrating to a suitable consistency the strained juice or the strained water extract from fruit, with sugar, or sugar and dextrose added. Sometimes pectin and/or an acid is also added. No less than 45 lbs. fruit are used to each 55 lbs. sugar or sugar and dextrose.

JOULE. Unit of energy. One joule is equivalent to 2390 gram calories, or 0.239 kilo Calories, or 0.000948 BTU.

JUMPED SEAM. Double seam which is not rolled tight enough adjacent to the lap, caused by jumping of the seaming rolls at the lap.

Kg. KILOGRAM or 1,000 grams, equivalent to 2.2046 lbs.

KILOCALORIE. See Calorie.

KILOGRAM (kg). A unit of weight in the metric system equivalent to 1,000 grams or 2.2046 lbs.

KNOCKDOWN FLANGE. Body hook and cover hook in contact, but not tucked in.

KRAFT. A term derived from a German word meaning strength, applied to pulp, paper, or paperboard produced from virgin wood fibers by the sulphate process.

LABEL. Any display of written, printed, or graphic matter on the container of any consumer commodity, affixed to any consumer commodity, or affixed to any package containing a consumer commodity.

LACQUER. See ENAMEL.

LAGOON. A large pond used to hold wastewater for stabilization by natural processes.

LAP. Two thicknesses of material bonded together. Section at the end of side seam consisting of two layers of metal to allow for double seaming. As the term implies, the two portions of the side are seam lapped together rather than hooked as in the center of the side seam.

LEACH. To subject to the action of percolating water or other liquid in order to separate soluble components.

LETHAL. Capable of causing death.

LEVULOSE. A highly soluble, simple sugar containing 6 carbon atoms. It crystalizes with great difficulty. It is sweeter than sucrose.

LID. Can end applied to open end of can in a cannery. Also known as top, cap or packer's end.

LIME. Calcium oxide, a caustic white solid, which forms slaked lime (calcium hydroxide) when combined with water.

LINER. Generally, any liner material that separates a product within a container from the basic walls of the container.

LIP. Irregularity or defect in double seam occurring at the lap. Due to insufficient tucking or cover hook resulting in a short cover hook and characterized by a blowing or sharp "V" projection at the bottom of the double seam. Also known as a "Droop".

LIQUID SUGAR. A concentrated solution of refined sucrose or of a mixture of sucrose and invert sugar.

LOCK SEAM. A seam formed by the two edges of a can body which have previously been edged or bent into hooks. The final seam is composed of four thicknesses of plate.

LOW-ACID FOODS. Any foods, other than alcoholic beverages, with a finished equilibrium pH value greater than 4.6 and a water activity greater than 0.85 and also includes any normally low-acid fruits, vegetables, or vegetable products in which for the purpose of thermal processing the pH value is reduced by acidification. Tomatoes, pears, and pineapples or the juices thereof, having a pH less than 4.7 and figs having a pH of 4.9 or below shall not be classed as low-acid foods.

LUG. A type of thread configuration; i.e., usually thread segments disposed equidistantly around a bottle neck (finish). The matching closure has matching portions that engage each of the thread segments.

LUG BOX. Large box used to haul fruit from fields to cannery.

LYE. A strong alkaline solution. Caustic soda (sodium hydroxide) is the most common lye.

LYE PEELING. Peeling a fruit or vegetable by soaking briefly in hot dilute sodium hydroxide, then scrubbing off the softened peel.

MAILLARD REACTION. A group of organic reactions, especially between amino acids and reducing sugars, producing brown color and flavor changes in many foods materials. Also known as non-enzymatic browning.

MAMMOTH GRADER. Large drum, perforated with graded holes, in which pears are graded progressively by size.

MATURATION. The process of developing quality in a product by aging under certain conditions.

MEAN. The average value of a number of observed data.

MESOPHILIC BACTERIA. Grow best at temperatures between 75° and 105°F; usually will not grow at temperatures below 50°F or above 110°F.

METER (m). Metric unit of length, equivalent to 39.37 in., or 3.28 ft.

Mg/1. Milligrams per liter; approximately equals parts per million (ppm). A term used to indicate concentration of materials.

MICROAEROPHILES. Organisms which grow best in the presence of small amounts of atmospheric oxygen.

MICROGRAM. One-thousandth part of a milligram; symbol μg.

MICROLITER. One-thousandth of a milliter.

MICRON. One-thousandth of a millimeter.

MIL. A unit of linear measurement, equivalent to 0.001 inch.

MINIMUM DAILY REQUIREMENTS (MDR). The minimum quantities of specified vitamins and minerals deemed necessary to avoid dietary deficiencies, as established by Food and Drug Administration labeling regulations in 1941 and later amendments. See UNITED STATES RECOMMENDED DAILY ALLOWANCES (U. S. RDA).

MIXTURE. Material composed of two or more substances, each of which retains its own characteristic properties.

mm. MILLIMETER. Equivalent to 0.001 meter, and to 0.0394 inch.

MOISTURE WATER VAPOR TRANSMISSION. The rate at which water vapor permeates through a plastic film or wall at a specified temperature and relative humidity.

MOLASSES. Syrup produced by washing raw sugar. It is boiled and as much sugar as possible crystalized out. The syrupy residue is molasses.

MOLDS. Microorganisms that belong to the fungi. The fungus body is usually composed of threads (hyphae, singular: hypha). These hyphae frequently branch in a more or less complex manner forming networks or webs, collectively called "mycellium". Hyphae may be one-celled or composed of many cells placed end to end. Fruiting bodies that grow from hyphae produce spores. Molds are much less heat resistant than bacteria.

MOLECULAR WEIGHT. Sum of the atomic weights of all the atoms in a molecule.

MOLECULE. The smallest theoretical quantity of a material that retains the properties exhibited by the material.

MONOSODIUM GLUTAMATE (MSG). See GLUTAMATE, SODIUM.

MULLEN TESTER. An instrument for testing the bursting strength of paper, paperboard, corrugated or solid fiberboard.

MYCELLIA. See molds.

MYCOSTAT. See FUNGISTATIC AGENT.

NECK. The part of a container where the bottle cross-section decreases to form the finish.

NEUTRALIZE. To adjust the pH of a solution to 7.0 (neutral) by the addition of an acid or a base.

NDGA See NORDIHYDROGUAIARETIC ACID.

NITRIFICATION. The process of oxidizing ammonia by bacteria into nitrites and nitrates.

NON-ENZYMATIC BROWNING. See MAILLARD REACTION.

NORDIHYDROGUAIARETIC ACID OR NDGA. Substance of plant origin used as an antioxidant for fats.

NOTCH. To cut away small portions of a blank usually at the corners to provide for features such as beading, double seaming, tongue profile, etc.

NUTRIENTS. Compounds that promote biological growth.

NUTRITION INFORMATION PANEL. Appears on food labels to the right of the principal display panel. It provides information on the nutritional composition of the food.

NUTRITIONAL INHIBITOR. A natural component of food which adversely affects the utilization of a nutrient.

OPEN LAP. A lap which failed due to various strains set up during manufacturing operations. Also caused by improper soldering.

OPEN TOP CAN. Another term for sanitary can.

ORGANOLEPTIC. See SENSORY.

OSMOPHILIC. Can grow or survive in a medium very low in humidity or of low water activity.

OSMOSIS. Diffusion between two miscible fluids separated by a permeable wall.

OVERLAP. The distance the cover hook laps over the body hook in a can double seam.

O/W EMULSION. Oil-in-water emulsion; oil is the discontinous or internal phase, water the continuous or external phase. An O/W emulsion is dispersible (dilutable) in water, but not in oil.

OXIDATION LAGOON. Synonymous with aerobic or aerated lagoon.

OXIDATION POND. Synonymous with aerobic lagoon.

PACKAGE. Any container or wrapping in which a consumer commodity is enclosed for delivery or display to retail purchasers.

PACKER'S END. The can end put on by the packer or canner. Also known as lid, cover, top, or canner's end.

PALATABILITY. Sensory attributes of foods, (e.g., aroma, flavor, texture, etc.) which affect their acceptability.

PALLET. A low, portable platform of wood, metal, firberboard or combinations thereof, to facilitate handling, storage and transportation of materials as a unit.

PALLETIZED UNIT LOAD. A unitized load fixed to a pallet.

PALLETIZING. The forming of a pallet load.

PANELING. Distortion (side wall collapses) of a container caused by development of a reduced pressure (too high vacuum) inside the container.

PAPER, WATER-RESISTANT. Paper that is treated by the addition of materials to provide a degree of resistance to damage or deterioration by water in liquid form.

PAPER, WET-STRENGTH. Paper that has been treated with chemical additives to aid in the retention of bursting, tearing or rupturing resistance when wet.

PASTEURIZATION. A heat treatment of food usually below 212°F, intended to destroy all organisms dangerous to health, or a heat treatment which destroys part but not all microorganisms that cause food spoilage or that interfere with a desirable fermentation.

PATHOGEN. Disease producing microorganism.

PATHOGENIC. Capable of producing disease.

PECTIN. Plant tissues contain protopectins cementing the cell walls together. As fruit ripens, protopectin breaks down to pectin, and finally to pectic acid under the influence of enzymes. Thus over-ripe fruit loses its firmness and becomes soft as the adhesive between the cells breaks down. Pectin is the setting agent in jams and jellies. The albedo of oranges and lemons, and apple pomace are commercial sources of pectin. Used as a gelling agent and as an emulsifier and stabilizer.

PECTIN METHOXYLASE. Enzyme in tomato juice that splits methyl alcohol from pectin leaving pectic acid, which does not have the colloidal and thickening properties of pectin. Inactivated by pasteurization.

PEMMICAN. Mixture of dried, powdered meat, and fat.

PERCOLATION. The movement of water through the soil profile.

PERMEABILITY. The passage or diffusion of a gas, vapor, liquid, or solid, through a barrier without physically or chemically affecting it.

PESTICIDE. A chemical which kills plant or animal pests.

PESTICIDE RESIDUES. Small amounts of pesticides remaining in foodstuffs as a result of pest control operations.

PETRI DISH. A double glass or plastic dish used in cultivating microorganisms.

pH. The effective acidity or alkalinity of a solution; not to be confused with the total acidity or alkalinity. The pH scale is:

ACID SOLUTIONS NEUTRAL ALKALINE SOLUTIONS
↓
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

pH 7 is the neutral point (pure water). Decreasing values below 7 indicate increasing acidity, while increasing values above 7 indicate alkalinity. One pH unit corresponds to a tenfold difference in acidity or alkalinity, hence pH 4 is 10 times as acid as pH 5 and pH 3 is 10 times as acid as pH 4 and so forth. The same relationship holds on the alkaline side of neutrality, where pH 9 is 10 times as alkaline as pH 8, and so on. Most meat and fish products have pH values between 6 and 7, vegetables have pH values between 5 and 7, and fruits have pH values between 3 and 5.

PICKING TABLE. The point where produce is manually inspected.

PICKLE LAG. The time required for hydrochloric acid to reach uniform rate of attack on tin plate. It is expressed in seconds.

PIN-HOLE. Synonym for perforation. Development of a small hole in the plate.

PLATE. Short name for tinplate, black plate, terne plate, aluminum plate, or any other basic rolled metal sheet.

PLATE, BLACK. See BLACK PLATE.

PLATE, COLD REDUCED. Plate produced by cold rolling of steel.

PLATE, DIFFERENTIAL. See TIN PLATE, DIFFERENTIAL.

PLATE, ELECTROLYTIC. See TIN PLATE, ELECTROLYTIC.

PLATE, TIN. See TIN PLATE.

POINT. Term used to describe the thickness of paperboard, a point being one thousandth of an inch.

POISONING, FOOD. See FOOD POISONING.

POTABLE. Drinkable.

POTASSIUM SORBATE. See SORBIC ACID.

POUCH. A small or moderate-sized bag, sack, or receptacle.

PPM. Parts per million. 1 ppm = 0.000,1 percent on weight basis. Also 1 mg/Kg = 1 ppm, and 0.032 oz/ton = 1 ppm.

PRESERVATION. Any physical or chemical process which prevents or delays decomposition of foods.

PRESERVATIVES. Any substance capable of retarding or arresting food spoilage or deterioration.

PRESSURE RIDGE. The pressure ridge is formed on the inside of the can body directly opposite the double seam, and is the result of the pressure applied by the seaming rolls during seam formation.

PRIMARY SPOILAGE. See also SECONDARY SPOILAGE. That spoilage due to bacterial or chemical action of product packed within the can.

PRIMARY WASTE TREATMENT. In-plant by-product recovery and wastewater treatment involving physical separation and recovery devices such as catch basins, screens, and dissolved air flotation.

PRINCIPAL DISPLAY PANEL. That part of a label on a food package that is most likely to be shown or examined under customary conditions of display for retail sale.

PROCESS EFFLUENT. The volume of liquid discharged from a plant. It is composed of water with dissolved and suspended solids.

PROCESS, SCHEDULED. The process selected by the processor as adequate under the conditions of manufacture for a given product to achieve commercial sterility. This process is in excess of that necessary to ensure destruction of microorganisms of public health significance.

PSIG. Pounds per square inch gauge pressure. For absolute pressure add 14.7 lbs. to psig pressure.

PSYCHROMETER. An instrument for measuring the humidity (water-vapor) content of air by means of two thermometers, one dry and one wet.

PSYCHROPHILIC BACTERIA. Have an optimum temperature for growth between 60° and 70°F. May grow at temperatures down to 32°F, and up to 86°F.

PTOMAINE. Term that has been used to describe certain types of food poisoning known today to be caused by toxins produced by bacteria.

PUNCTURE TEST. A test to determine resistance of flexible packaging materials to puncturing.

PUREE. In food technology, a smooth, pulpy, thick fluid produced by very finely disintegrating a juicy food commodity such as a fruit or vegetable.

PUTREFACTION. Decomposition of proteins by microorganisms, producing disagreeable odors.

QUALITY CONTROL. A system for assuring that commercial products meet certain standards of identity, fill of container, and quality sanitation, and adequate plant procedures.

RANCIDITY (RANCIDIFICATION). An oxidative deterioration in food fat whereby a typical off-odor and/or flavor is produced.

RAW WASTE. The wastewater effluent from the in-plant primary waste treatment system.

RECYCLE. The return of a quantity of effluent from a specific unit or process to the feed stream of that same unit. This would also apply to return of treated plant wastewater for several plant uses.

REFRACTOMETER (ABBE REFRACTOMETER). Optical instrument that measures the percent of soluble solids in solution by the extent to which a beam of light is bent (refracted). Soluble solids scale is based on sugar concentration in a pure sucrose solution.

RELATIVE HUMIDITY. The ratio of actual humidity to the maximum humidity which air can retain without precipitation at a given temperature and pressure. Expressed as percent of saturation at a specified temperature. See also ABSOLUTE HUMIDITY.

REVOLVING DRUM TEST. A test for measuring the protection to contents, or the retention properties of a container, or both by subjecting the packaged products to rough handling in a standard revolving drum.

RETORT. Any closed vessel or other equipment used for the thermal sterilization of foods.

RHEOLOGY. Study of the deformation and flow of matter.

ROD. See BACILLUS.

ROTARY WASHER. A common type of washer in which produce is tumbled and washed by sprays of water.

SALMONELLA. Enteric pathogenic bacteria that may grow in foods and cause food infections, or may be commonly only transported by foods. Can survive in brine and at refrigerator temperature. Destroyed by adequate heating as in the canning process.

SANITARY CAN. See CAN,SANITARY .

SANITIZE. To reduce the microbial flora in or on articles such as food plant equipment or eating utensils to levels judged safe by public health authorities.

SANITIZER. A chemical agent that reduces the number of microbial contaminants on food contact surfaces to safe levels from the standpoint of public health requirements. Sanitizing can also be done by heating.

SAPONIFICATION. The process of hydrolysis of fats of oils of a fluid by an alkali to form soap.

SCREENING. The removal of relatively coarse floating and suspended solids from wastewater by straining through screens.

SEALING SURFACE. The surface of the finish of the container on which the closure forms the seal.

SEAM COMPOUND. Rubber or other material applied inside can end curl to aid in forming a hermetic seal when end is double seamed.

SEAM, THICKNESS. The maximum dimension measured across or perpendicular to the layers of the seam.

SEAM, WIDTH. The maximum dimensions of a seam measured parallel to folds of the seam. Also referred to as the seam length or height.

SEAMER. Machine for double seaming can ends to the body of the can.

SECOND OPERATION. The finishing operation in double seaming. The hooks formed in the first operation are rolled tight against each other during the second operation.

SECONDARY SPOILAGE. Consists of those cans rusted or corroded as a result of bursting or leaking cans. May occur during warehousing.

SECONDARY TREATMENT. The waste treatment following primary in-plant treatment, typically involving biological waste reduction systems.

SEDIMENTATION. The falling or settling of solid particles in a liquid, as a sediment.

SENSIBLE HEAT. See HEAT, SENSIBLE.

SENSORY (SENSORY PROPERTIES). Pertaining to an impact of a food on the senses (e.g., vision, odor, taste, tactile senses).

SEQUESTERING AGENT. See ETHYLENEDIAMINE TETRA-ACETIC ACID.

SETTLING TANK. Synonymous with "Sedimentation Tank".

SEWAGE. Water after it has been fouled by various uses.

SIDE SEAM. The seam joining the two edges of a blank to form a can body.

SILKER. Usually a reel-type washer for desilking ears of corn.

SIZE GRADER. Belts or rotary drums with graduated holes through which produce can be sized mechanically.

SHELF LIFE. The length of time that a container, or a material in a container, will maintain market acceptability under specified conditions of storage. Also known as merchantable life.

SLIPPER. A can having an incompletely finished double seam due to the can slipping on the base plate. In this defect, part of the seam will be incompletely rolled out. Term has same meaning as dead head when referring to seamers which revolve the can.

SLUDGE. The accumulated settled solids deposited from sewage or other wastes, raw or treated, in tanks or basins, and containing more or less water to form a semi-liquid mass.

SOFT SUGARS. Highly refined, dark colored, molasses-flavored sugars which are frequently called brown sugars. They have a relatively high content of mineral and other nonsucrose materials.

SOFT SWELL. Both ends of can swelled, but may be depressed fairly easily by thumb pressure.

SORBIC ACID. Used to selectively inhibit growth of yeasts and molds.

SPINNER. A container with a faulty double seam, caused by the container having been revolved by the seaming rolls, due to improper adjustments.

SPOILAGE. A process whereby food is rendered unacceptable through microbial or chemical action. See also PRIMARY SPOILAGE and SECONDARY SPOILAGE.

SPORES. Certain of the rod forms of bacteria produce spores. These are not reproductive bodies, as in the case of molds and yeasts, but are the resting stage of the organism. In the spore state, bacteria can survive extremes of cold, heat, drying, and other unfavorable conditions for long periods of time; and when the environment is again favorable, the spores germinate, and the organisms start another cycle of growth. Growing cells are called "vegetative" cells. Sporeforming bacteria which can grow in the presence or absence of air (facultative anaerobes) are classified in the genus Bacillus, while those which grow only in the absence of air are classified in the genus Clostridium.

SPRAY DRIER. Equipment in which material to be dried is sprayed as a fine mist into a hot-air chamber and falls to the bottom as dry powder. Period of heating is very brief. Dried powder consists of hollow particles of low density.

SPRINGER. Swelled can with only one end remaining out; on pressing this end it will return to normal, but the other end will bulge out.

STABILIZERS. Substances that stabilize emulsions.

STALING. A physical-chemical process in cereal products, especially bread, whereby a characteristic "dry" texture develops.

STANDARD DEVIATION. Statistical measure of the scattering of data from the average; equal to the root mean square of the individual deviations from average.

STAPHYLOCOCCI. Spherical bacteria (cocci) occurring in irregular, grape-like clusters.

STEAM-FLOW CLOSING MACHINE. Equipment to close containers while at the same time producing a vacuum in them by means of steam jets directed into and around the container.

STERILE. Free of living organisms. See also COMMERCIAL STERILITY.

STERILITY (OF FOOD), COMMERCIAL. See COMMERCIAL STERILITY.

STERILIZATION. Any process, chemical or physical, which will destroy all living organisms.

STERILIZATION PROCESS. The time-temperature treatment necessary to render canned foods commercially sterile.

STERILIZATION TIME. The time that lapses between the moment a retort reaches sterilization temperature, until steam is cut off.

STORAGE LIFE. See SHELF LIFE.

STREPTOCOCCI. Cocci that divide in such a way that chains are formed.

SUCROSE. A sweet crystallizable, colorless sugar which constitutes the principal sugar of commerce. Refined cane and beet sugars are essentially 100% sucrose. Under certain conditions sucrose breaks down to dextrose and levulose.

SURFACE-ACTIVE AGENT. Substance that affects the surface tension of a liquid. They include emulsifying agents, detergents, suspending agents, wetting agents, etc.

SURFACTANT. Surface-active agent.

SUSPENDED SOLIDS. The quantity of solids, both volatile and stable, in suspension which can be filtered out by a standard filter under a specified test procedure.

SWELL. (1) (Noun) A container with either one or both ends bulged by moderate or severe internal pressure. (2) (Verb) To bulge out by internal pressure, as by gases caused by biological or chemical action.

SWELL, HYDROGEN. See HYDROGEN SWELL.

SYNERESIS. Exuding of small amounts of liquids from gels.

SYRUP. Water solution of sugar, usually sucrose.

TEMPER. A measure of the ductility and hardness of steel plate.

TENDEROMETER. Instrument to measure the stage of maturity of peas to determine if they are ready for canning. Measures the force required to effect a shearing action.

TERNE PLATE. Black plate coated on both sides by hot dipping in an alloy containing approximately 15% tin and 85% lead. Due to the lead content, terne plate is unsuitable for food products.

TERTIARY WASTE TREATMENT. Waste treatment systems used to treat secondary treatment effluent and typically using physical-chemical technologies to effect waste reduction.

THERMOCOUPLE. A bi-metallic device to measure temperatures electrically.

THERMODURIC. Microorganisms that have the ability to withstand high temperatures, i.e., are highly heat resistant.

THERMOLABILE. Fairly easily destroyed by heat.

THERMOPHILIC BACTERIA. Describes bacteria which require temperatures between 100°F and 180°F for growth and grow optimally at 122° to 131°F.

TIN PLATE. Sheet steel, usually of special formula and temper, coated on both sides with a controlled thickness of pure tin.

TIN PLATE, CHARCOAL. A type of hot-dipped, tin-coated steel plate ranging from an average of 2.2 to 7 lbs. of tin per base box. For can manufacturing purposes in the U.S. this type of plate has been completely replaced by electrolytic plate.

TIN PLATE, COKE A class of hot-dipped, tin-coated steel plate which carry tin in the range of 1.25 to 1.75 lbs. per base box. Now little used in the U.S.

TIN PLATE, DIFFERENTIAL. Electrolytic tin plate having different weights of tin coatings on opposite sides of the sheet.

TIN PLATE, ELECTROLYTIC. Black steel plate which has been coated on both sides by electro-deposition of commercially pure tin. Coating weights available are generally lower than on hot-dipped. Most frequently used weights are 0.25, 0.50, 0.75 and 1.00 lb. of tin per base box (No. 25, No. 50, No. 75, and No. 100), the exact weight depending on the intended application.

TIN PLATE, HOT-DIPPED. Black plate which has been coated on both sides with commercially pure tin by a process wherein, after pickling, the sheets are passed successively through flux, molten tin and palm oil. The amount of coating can be varied to meet the requirements from a minimum of about 1.25 lb. per base box. Now little used in the U.S.

TIN PLATE, TYPE "L". Tin plate in which the base plate is low in copper and metalloids (S, As, P, etc.). Such plate has maximum corrosion resistance to highly corrosive foods.

THERMOPHILES. Bacteria which grow optimally above 113°F.

TOLERANCE. A specified allowance for deviations in weighing, measuring, etc., from the standard dimensions or weight.

TOMATO KETCHUP, CATSUP OR SAUCE. Product made of tomato puree, vinegar, sugar, salt, and spices.

TOP DOUBLE SEAM. The double seam formed by end attached by canner. Also known as packer's end seam.

TOTAL DISSOLVED SOLIDS (TDS). The solids content that is soluble and is measured as total solids content minus the suspended solids.

TOTAL SUSPENDED SOLIDS (TSS). Solids found which in most cases can be removed by filtration.

TOXIN. An organic poison, a product of the growth of an organism. Some toxins are given off as waste products of a microorganism, and are called "exotoxins". Others are contained within the cells, and are liberated only when the cell dies and disintegrates. These are called "endotoxins". Toxins produced by *Clostridium botulinum* are thermolabile, that is, they are fairly easily destroyed by heat.

TRANSLUCENT. Descriptive of a material or substance capable of transmitting some light, but not clear enough to be seen through.

TRANSPARENT. Descriptive of a material or substance capable of a high degree of light transmission. (e.g., glass).

TRIM TABLES. Area where produce are hand cut and trimmed.

ULTRA-VIOLET IRRADIATION. Lethal to many species of bacteria, but of poor penetrating power, thus only of value for surface sterilization or sterilizing the air.

UNITED STATES RECOMMENDED DAILY ALLOWANCES (U.S. RDA). Amounts of protein, 12 vitamins, and 7 minerals set by the Food and Drug Administration in 1973 as a revision of the MDR and utilizing the NAS/NRC Recommended Dietary Allowances as a base.

UPERIZATION. A method of sterilizing fluid foods by injecting steam under pressure to raise the temperature to 150°C (302°F). The added water is evaporated off.

VACUUM PACKAGING. Packaging in containers, whether rigid or flexible, from which substantially all gases have been removed prior to final sealing of the container.

VEGETATIVE CELLS. Stage of active growth of the microorganism, as opposed to the bacterial spore.

VENTING. Eliminating air from a retort prior to sterilizing canned foods.

VENTS. Openings controlled by gate, plug, cock, or other adequate valves used for the elimination of air during the venting period.

VIABLE. Living.

VINER. Equipment for removing peas, lima beans, and green beans from the vines on which they are harvested. In the case of peas and lima beans, viners also remove vegetable from the pod.

VISCOSITY. Internal friction or resistance to flow of a liquid. The constant ratio of shearing stress to rate of shear. In liquids for which this ratio is a function of stress, the term "apparent viscosity" is defined as this ratio.

VORTEX WASHER. Circular tank in which produce is washed by sprays which impart a swirling motion.

WASHERS. Equipment made in a variety of designs for washing produce prior to sizing, grading, trimming and blanching.

WATER ACTIVITY. A measure of water availability in food for microbial growth. The ratio of the water vapor pressure of a food to the vapor pressure of pure water under identical conditions of temperature and pressure.

WEAK LAP. The lap is soldered and both parts are together. However, strain on this lap, as twisting with the fingers, will cause the solder bond to break.

W/O EMULSION. Water-in-oil emulsion in which the water is the internal phase and the oil is the external or continuous phase. When diluted by the addition of an oil, W/O emulsions retain homogenity.

WRINKLE, COVER HOOK. A degree of waviness occurring in the cover hook, acting as an indication of the tightness of the seam. Several numerical rating systems are used.

XEROPHILIC. Can grow or survive in a medium very low in humidity.

YEASTS. Spherical or more or less elongated cells, varying in normal width from 1/10,000th to 1/2,000th of an inch. Most yeasts break down sugars to carbon dioxide and alcohol. That process is called fermentation.

SUBJECT INDEX