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1 Scope and objective

This Code applies to the receiving, preparation, processing, handling, storage, transport, distribution, and retailing of all quick frozen foods such as cereals, fruits and vegetables, fish, meat, poultry and their products, bakery and pastry products. The Code does not apply to edible ices, ice creams and milk.

The objective of this Code is to provide guidance for the processing and handling of quick frozen food to help ensure product safety and other aspects of the production of quick frozen foods including, as appropriate, essential quality provisions, composition and labelling provisions of pertinent Codex commodity standards. The guidance, emphasizing proper cold chain management, incorporates good hygienic and good manufacturing practices and the application of the Hazard Analysis and Critical Control Point (HACCP) approach described in the HACCP Annex to the *General Principles of Food Hygiene* (CAC/RCP 1-1969). A prerequisite programme is described in the Code, covering essential requirements of hygiene in the production of quick frozen foods that should be in place prior to the application of HACCP.

The food hygiene provisions of this document are supplemental to, and must be used in conjunction with the *General Principles of Food Hygiene* (CAC/RCP 1-1969). The Code should also, as appropriate, be used in conjunction with other Codex texts, including the *General Standard for the Labelling of Prepackaged Foods* (CODEX STAN 1-1985), codes of hygienic practice (e.g. *Code of Hygienic Practice for the Transport of Food in Bulk and Semi-Packed Food* (CAC/RCP 47-2001), *Code of Hygienic Practice for Meat* (CAC/RCP 58-2005)), codes of practice (e.g. *Code of Practice for Fish and Fishery Products* (CAC/RCP 52-2003)) as well as the *Guidelines for the Validation of Food Safety Control Measures* (CAC/GL 69-2008). Reference can also be made, as appropriate, to Codex quick frozen food standards and/or provisions in relevant Codex texts.

This Code including its Annex is intended to assist all those who are engaged in the processing and handling of quick frozen foods and/or are concerned with their storage, transportation, export, import and sale in attaining safe food products of appropriate quality.

In addition, the Code may be used for training of employees of the quick frozen food industry. The application of this Code is likely to require modifications and amendments, taking into account local conditions and specific consumer requirements.

2 Terms and definitions

2.1
blanching
heat process typically applied to a food for the purpose of inactivating enzymes and/or fixing the product colour

2.2
cold chain
term embracing the continuity of successively employed means to maintain the temperature of foods, as appropriate, from receiving through processing, transport, storage and retailing

2.3
prerequisite programme
programme required prior to the application of the HACCP system to ensure that any component of the cold chain is operating according to the *General Principles of Food Hygiene* (CAC/RCP 1-1969) appropriate Codex codes of practice, and other appropriate food safety legislation

2.4
quick freezing process
process which is carried out in such a way that the range of temperature of maximum ice crystallization is passed as quickly as possible

2.5
quick frozen food
food which has been subjected to a quick freezing process, and maintained at -18°C or colder at all points in the cold chain, subject to permitted temperature tolerances

2.6
responsible competent authority
refers to the regulatory agency responsible for the implementation of official food control system to ensure public health and safety across the food supply chain

2.7
thermal centre
point within a piece of food which has the highest temperature at the end of a quick freezing process

2.8
tolerances
short term fluctuations of temperature of the product in the cold chain, within limits permitted in this Code and which do not affect safety and quality

3 Prerequisite Program

In conjunction with the application of HACCP to any segment of the quick frozen food chain, that segment should be supported by prerequisite programmes based on good hygienic practice and good manufacturing practice. Prerequisite programmes should be specific within an individual establishment, and should be periodically evaluated to ensure their continued effectiveness.

While prerequisite programmes are usually associated with food safety, properly operating prerequisite programmes will also contribute to product quality.

Reference should be made to the *General Principles of Food Hygiene* (CAC/RCP 1- 1969) and relevant Codex codes of hygienic practice and codes of practice including the *Guidelines for the Validation of Food Safety Control Measures* for further information to assist with the design of the prerequisite programmes for a processing facility.

In addition to the provisions of the *General Principles of Food Hygiene* (CAC/RCP 1-1969) the following additional prerequisite provisions should apply:

3.1 Establishment: Design and Facilities

3.1.1 Location

Processing facilities should, to the extent possible, be located close to the source of raw materials so as to minimize changes that might lead to quality or safety concerns for raw materials of quick frozen foods prior to freezing.

3.1.2 Process Plant Design

The food processing facility should be designed for the rapid processing, freezing and storage of food products. The processing facility should include a product flow that is designed to minimize process delays and prevent cross-contamination that could affect food quality and safety.

3.1.3 Cold Store Design

The cold store walls, floor, ceiling, and doors should be properly insulated in order to help maintain appropriate product temperatures. It is important that the design of the cold store ensures that:

a) adequate refrigeration capacity provides and maintains a product temperature of -18°C or colder;

b) there is adequate air flow around the stored foods;

c) storage areas are provided with a capability to control and record temperatures on a regular basis;

d) loss of cold air and introduction of warm and humid air are avoided; and

e) leaks of any refrigerant are prevented. In case of a leak, immediate corrective action ought to be applied in order to eliminate the problem.

3.1.4 Equipment Design and Construction

The equipment should be designed and constructed in such a manner that physical damage to the raw materials and product is minimized, e.g. by ensuring there are no sharp inside corners or projections and that physical, chemical or biological hazards are not introduced into the product. Freezers should be designed and constructed so that, when properly operated, they meet the requirements of a quick freezing process.

3.1.5 Facilities

In the case of power losses or equipment failure, a contingency plan should be in place in order to maintain the product temperature.

3.2 Control of Operation

3.2.1 Recall Procedures

Recall procedures should be in place to ensure timely withdrawal of products that may pose a risk to human health.

3.2.1.1 Traceability/Product Tracing

The traceability/product tracing system should be designed and implemented according to the *Principles for Traceability/Product Tracing as a Tool within a Food Inspection and Certification System* (CAC/GL 60-2006), especially to enable the withdrawal of the product, where necessary.

3.3 Establishment: Maintenance and Sanitation

3.3.1 Maintenance Regimes

Proper maintenance and repair of any damage to the cold store and its infrastructure (e.g. prevention of rust, water leaks, ice accumulation, etc.) should be ensured so that insulation and refrigeration performance is maintained.

3.4 Training

Staff should have the skills and knowledge appropriate to their work to ensure that safety and quality of foods is not adversely affected during handling. Staff should also be aware of the importance of maintaining temperature control for frozen foods to maintain the quality and safety of the foods. Training programs should be in place (either formal training courses or training provided whilst working) to ensure that staff have these skills and knowledge.

4 Cold Chain Control

As appropriate, both safety and quality aspects should be considered for each operation of the cold chain.

With respect to food safety, a HACCP plan should be developed, as appropriate, for each operation in the cold chain.

Cold chain control is also important with respect to food quality. Essential quality provisions can apply at various points in the processing and handling system. While control of essential quality provisions may be considered optional, control of food safety hazards through prerequisite programs and a HACCP plan should be used, as appropriate, to ensure safety.

4.1 Raw materials

Raw materials used should be safe, sound and suitable for further processing.

Procedures should be in place to ensure quality and safety of incoming materials. Freezing cannot improve quality, and it is necessary to use raw materials of optimum quality. Many raw materials and food products are highly perishable and should be handled carefully to maintain their quality until the freezing process is initiated.

Initial microbial levels in raw materials to be frozen should be kept as low as possible, both for food safety and quality reasons. Temperatures and duration of storage should be appropriately and regularly controlled to minimize adverse microbial effects. Most quality deterioration, including the development of off odours and flavours and changes in colours and texture are due to microbial growth or enzymatic activity.

Producers of quick frozen food should as far as practicable implement measures to control physical, biological and chemical hazards in raw materials to levels that do not present a threat to human health according to the recommendations of the relevant sections of the *General Principles of Food Hygiene* (CAC/RCP 1-1969) and other relevant Codex texts.

Appropriate procedures should be in place for sorting and segregating raw materials that are unsuitable for further processing. Raw materials for processing and quick freezing should be prepared without delay and appropriate temperature control should be applied in order to minimize possible microbiological, chemical or biochemical changes that might affect safety and quality. To minimize deterioration, raw materials should be cooled and stored under appropriate conditions (e.g. pre-cooling) or transported and frozen in the shortest time possible.

For highly perishable products, product temperature control at receiving may be considered a critical control point (CCP). Additionally, the receipt temperature may also be considered an essential quality provision.

4.2 Processing before freezing

Raw materials may be processed in many ways before freezing, e.g. cleaning, sorting, cutting, slicing, blanching, conditioning, ageing, scalding, filleting and heating. Whether such processes should be regarded as CCPs depends on the type of raw materials and the actual conditions, especially on how much time the raw materials and the resulting product spend at temperatures that could result in pathogen growth. It is particularly important that the time spent in the critical temperature zone (i.e. between 10°C and 60°C) be as short as possible. Consideration should also be given to any of these processes as to whether or not they should be regarded as an essential quality provision.

Blanching is often used in the production of frozen vegetables and other products to inactivate enzymes that would cause quality problems (taste, color) during frozen storage. The blanching schedule should be determined to ensure the desired quality outcome, and may be an essential quality provision.

If storage of intermediate ingredients (e.g. a quick frozen vegetable that is to be combined with other quick frozen vegetables or other ingredients into a final product) is necessary prior to further processing, the storage conditions, especially temperature, should be appropriate to the foodstuff concerned and if necessary, take into account future use or further processing of the food.
The heat treatment of many pre-cooked foods, e.g. prepared meals, should be sufficient to ensure inactivation of pathogens of concern. In certain cases, based on the hazards and controls specified for an operation, the time-temperature treatment and subsequent cooling may be considered as CCPs.

If frozen raw materials are used and a thawing process is included, the thawing method should be clearly defined and the thawing schedule (time and temperature parameters) should be carefully monitored. Selection of the thawing method should take into account the thickness and uniformity of size of the products in particular. Thawing should be done in such a manner that the growth of microorganisms is controlled. Thawing time and temperature parameters may be a CCP and/or an essential quality provision.

4.3 Quick Freezing Process

The quick freezing process should be performed in such a manner as to minimize physical, biochemical and microbiological changes, by taking into account the freezing system or process and its capacity, nature of the product (thermal conductivity, thickness, form, initial temperature) and volume of production. This is best achieved by ensuring that the product passes quickly through the temperature range of maximum ice crystallization. This temperature range varies among different types of products. The quick freezing process step may be considered an essential quality provision.

During freezing operation it is important to provide spaces or channels permitting air circulation between the cartons or the pieces of food, respectively. This is especially the case when large lots of food are frozen or where the food consists of large pieces (e.g. whole turkeys). If such air channels are not provided, the mass of the food may be such that in spite of rapid air blast and low air temperatures, the inner parts of the lot chill and freeze slowly. It is important that the thermal centre of the product is chilled as quickly as possible to prevent the outgrowth of pathogenic microorganisms or the production of microbial toxins. Freezing may be a CCP.

The quick freezing process should not be regarded as complete until and unless the product temperature has reached -18°C or colder at the thermal centre, after the stabilization of the temperature. On exit from the freezing apparatus, the product should be moved to a cold store as quickly as possible in order to minimize exposure to warm temperatures and high humidity and to maintain the product temperature at -18°C or

colder. The same applies to products that are retail packed after the quick freezing process (see Section 4.8).

4.3.1 Impact of Quick Freezing on Microorganisms and Parasites

Freezing should not be considered as a lethal treatment for microbiological contamination in foods. However, freezing may result in the death of certain microorganisms and will inhibit the growth of others.

In products intended for raw consumption or not fully cooked prior to consumption, freezing can be used to control live helminth parasites, such as *Anisakis spp.* and *Trichinella spiralis.* Freezing may serve as a control mechanism when developing HACCP plans for marinating, pickling, or other final preparations which do not supply sufficient heat from cooking to inactivate any potentially harmful parasites. The conditions required for effective parasite control using freezing include the final temperature and time of holding in the frozen state. These parameters vary depending on a number of factors which may include the type of commodity, species of parasite, thickness of the product, and arrangement of product in the freezer. The use of freezing as a food safety control measure should, as with all food safety control measures, be appropriately validated to ensure that the measure is capable of controlling the hazard.

4.4 Processing after freezing

Glazing may be used to limit dehydration during frozen storage. Such dehydration may affect the appearance and other quality parameters of the food. The application of glazing should be properly controlled.

4.5 Packaging and labelling

4.5.1 Packaging

In general, the packaging should:

a) protect the food against dehydration;
b) protect the food against microbial and other contamination that could adversely affect safety and quality;
c) protect the sensory and other quality characteristics of the food; and
d) not add to the food any substance that may influence the safety and quality of the food.

The packaging or re -packing of quick frozen foods should be carried out in such a manner that an increase in temperature, within the permitted tolerances of the quick frozen foods, does not adversely affect the safety and quality of the product.

4.5.2 Labelling

The labelling of packaged quick frozen foods should comply with the requirements of the *General Standard for the Labelling of Prepackaged Foods* (CODEX STAN 1-1985) and the relevant Codex standards for quick frozen foods.

Proper labelling includes information that instructs the consumer regarding safe handling practices and, where appropriate, briefly informs the consumer of the food safety issue. It shall comply with the guidelines set by the responsible competent authorities.

4.6 Frozen Storage

Cold stores should be designed and operated so as to maintain a product temperature of -18°C or colder with a minimum of fluctuation (see Section 3.1.3). The temperature of the cold store may be an essential quality provision and/or a CCP to avoid a critical temperature abuse situation that may jeopardize food safety.

Stock should be placed in the cold room in such a manner that the circulation of cold air is not impeded to the extent that the product temperature is adversely affected.

Stocks should be rotated to ensure that the products leave the cold store on a “First in-First out” basis or shortest durability date. In no case, should products be stored beyond their specified shelf-life.

4.7 Transport and distribution

The product temperature during transport and distribution may be an essential quality provision and/or a CCP to avoid a critical temperature abuse situation that may jeopardize food safety. The transport of quick frozen foods (e.g. from cold storage warehouse to cold storage warehouse) should be carried out in suitably insulated equipment that ideally maintains a product temperature of -18°C or colder. The product temperature should be at -18°C or colder at the beginning of the transport.

Vehicle compartments or containers should be pre-cooled prior to loading. Care should be taken not to impair the efficiency of temperature control or reduce the refrigeration capacity.

The user of the vehicle or container should ensure:

- adequate supervision of product temperatures at the moment of loading;
- effective stowage of the load in the vehicle or the container to protect the cargo against heat entering from outside;
- efficient operation of the refrigerating unit during transit, including the correct thermostat setting;
- an appropriate method of unloading at the points of arrival (particularly the frequency and duration of door openings);
- proper maintenance of the insulated body and the refrigeration system; and
- proper cleaning of the vehicle or container.

Distribution of quick frozen foods should be carried out in such a way that any rise in product temperature warmer than -18ºC be kept to a minimum within, as appropriate, the limit set by responsible competent authorities and should not in any case be warmer than -12ºC in the warmest package to ensure quality of the products. After delivery, the product temperature should be reduced to -18°C as soon as possible.

Loading into and unloading from vehicles and loading into and unloading from cold stores should be as fast as practicable and the methods used should minimize product temperature rise.

4.8 Transfer points

Attention should be paid to moving quick frozen foods as rapidly as is reasonably practicable from cold store to vehicle/container or from vehicle/container to holding store or from holding store to display cabinets. Often, transfer of responsibility occurs at the same time.

- Quick frozen foods should not be left for any significant length of time at ambient temperature.
- Procedures should be established for dispatching loads and for immediate storage of food upon arrival, in order to minimize exposure to humidity, elevated temperatures or other adverse conditions.
- It should be established that all personnel are following such procedures.
- The product temperature should be checked as necessary, as the product is received or dispatched and a record of these measurements retained for a period that exceeds the shelf-life of the product.
- Operations (such as casing, order assembly, palletizing, etc.) should be carried out in the cold store or in a suitably temperature-controlled area.

4.9 Retail Sale

Quick frozen foods should be offered for sale from freezer cabinets designed for the purpose. Cabinets should be capable of maintaining and be so operated as to maintain a

product temperature of - 18°C. A rise in product temperature may be tolerated for short periods, with any rise warmer than -18ºC kept to a minimum, within, as appropriate, the limit set by responsible competent authorities, and should not in any case be warmer than -12ºC in the warmest package.

Temperature in the cabinet may be an essential quality provision and/or a CCP to avoid a critical temperature abuse situation that may jeopardize food safety.

Display cabinets should:

- be equipped with an appropriate temperature measuring device (see Annex, Section 2.4);
- be located so that the open display area is not subject to draughts or abnormal radiant heat (e.g. direct sunlight, strong artificial light or in direct line with heat sources); and
- never be stocked beyond the load line.

Cabinets requiring defrosting should have the defrost cycle programmed in such a way that, to the extent possible, defrosting takes place outside peak shopping periods. If necessary to avoid detrimental effects due to warming or thawing, quick frozen foods should be moved during defrost cycles to a suitable cold store.

Stocks should be rotated to ensure that the products are sold on a “First in-First out” basis or shortest durability date. In no case, should products be stored beyond their specified shelf-life.

The retail establishment should have an appropriate back-up storage for quick frozen foods that allows products to be kept at a temperature of -18º

5 Temperature management in the cold chain

Inadequate food temperature control is one of the most common causes of food borne illness. Inadequate food temperature control may also result in an adverse effect on product quality, including food spoilage. Temperature management systems should be in place to ensure that the temperature along the cold chain is controlled and monitored effectively. Details on temperature control and temperature monitoring are provided below and in the Annex, which provides additional guidance and explanation on currently available technology on temperature monitoring and control in the cold chain.

5.1 Temperature monitoring

Operators should ensure that appropriate systems are in place to monitor air temperatures during the freezing process and to monitor temperature along the cold chain in order to

ensure that the product temperature is maintained at -18ºC or colder within the permitted tolerances set by responsible competent authorities.

In general, operators have a choice of monitoring systems for quick frozen products, which either include measurement of operating air temperatures of the refrigerating systems or direct/indirect measurement of product temperature. Additional approaches also exist (see Section 5.1.3).

5.1.1 Air Temperature Monitoring

In air temperature monitoring, fixed temperature sensors are used to monitor the air temperature in the refrigerated system. The sensors are normally protected from damage during commercial activity.

Air temperature monitoring permits:

- diagnosis of problems occurring in the system; and
- process management using data storage on computers, which can be linked to other operating information such as defrost cycles, door openings, energy consumption and production batch codes.

5.1.2 Product Temperature Monitoring

Product temperature may be measured directly or indirectly. Direct measurements of product temperature may be undertaken destructively or non-destructively. Although product temperature measurement can give more confidence than air temperature monitoring that temperature requirements are being complied with, this approach is often not practical during busy production and distribution periods.

5.1.3 Additional Approaches

Additional approaches to temperature monitoring include:

- use of a simulated food product;
- use of temperature probes and/or recorders, as appropriate, placed between packages or in a load;
- use of a non-contact thermometer; and
- use of temperature indicators and time-temperature indicators.

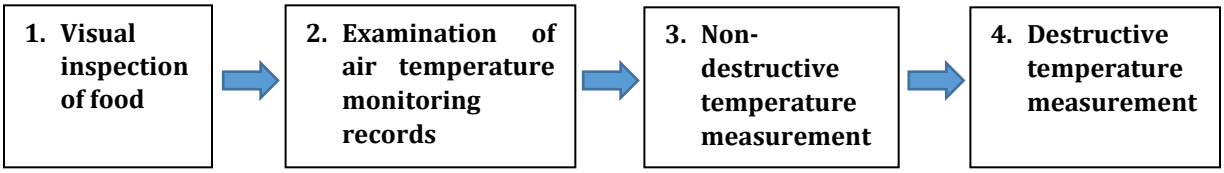
5.1.4 Temperature monitoring equipment

The selection of temperature monitoring equipment should take into account:

- appropriate accuracy and resolution (depends on the construction of the equipment and its use);
- ability to withstand vibrations, shocks or movement (for mobile system);
- coverage of temperature range adequate for quick frozen foods; and
- need for calibration and periodic checks to ensure proper functioning.

5.2 Stepwise approach to temperature control

When quick frozen foods are being inspected in the cold chain, either before loading or during unloading, a stepwise approach is recommended.



1. First, before loading and during unloading, a visual inspection is recommended in order to verify the condition of the foods (e.g. for signs of damage, abuse, defrosting).

2. Second, the air temperature monitoring records and other temperature readings noted in the documentation following the foods should be examined. If the loading temperature was correct and the refrigeration system functioning correctly, and there are no irregularities in the temperature difference between the air leaving the refrigeration unit and the air return, no further action need be taken.

3. A non-destructive product temperature measurement should be carried out, especially if there is a doubt about any of the above aspects or no records are available. This should involve a between carton or between package temperature reading (see Annex, Section 3.1.3). If the non-destructive measurement indicates that the product temperature is within the permitted tolerances set by responsible competent authorities, the inspection may stop at this point.

4. If the non-destructive product measurement indicates that the product temperature is outside the permitted tolerances, a destructive temperature measurement should be undertaken (see Annex, Section 3.1.4). This operation must be carried out after placing the cargo in refrigerated environments or after protecting the load in order to avoid increasing the temperature of the food.

Whenever this stepwise approach indicates a temperature violation, the procedure in Section 5.3 should be followed.

5.3 Temperature violation

Loads or parts of loads that are warmer than the temperature required for quick frozen food should be identified and sorted immediately. Delivery, and sale of these loads or parts of loads should be suspended. It is the responsibility of the person in possession of the food to ensure the food safety of the product. Any measures necessary for preserving the food should be taken, including bringing down the temperature immediately. An assessment should be made as to whether the safety or the quality of the product has been compromised and action taken accordingly. Destruction of the product may be necessary, especially if safety provisions are compromised. In cases of compromised safety or quality, the supplier, as well as other relevant parties in the supply chain should be informed of the incident. In the case of compromised safety the responsible competent authorities should also be notified.

5.4 Record keeping

Records of these measurements should be kept for a period that exceeds the shelf-life of the product or as required by responsible competent authorities.

ANNEX

SPECIFIC INFORMATION ON TEMPERATURE MONITORING AND CONTROL IN THE COLD CHAIN

1 Introduction

This Annex provides additional guidance and explanation on currently available technology on temperature monitoring in the cold chain. New temperature measuring and recording devices may be developed and should be used as appropriate.

2 Air temperature monitoring

2.1 Air temperature monitoring equipment

Temperature measurement and recording devices consist of a sensor (placed in the cold air), and a read-out or recording system. The sensor can be located far from the read-out or recording system or incorporated in it. A recorder is able to store the data, usually electronically, although chart recorders are still widely used for cold stores and containers.

- Air temperature measurement and recording devices should be accurate to within ± 2°C and have a resolution of 1°C. The response time, i.e. the time taken for readings to stabilize, depends on the construction of the equipment and its use. Also if the system is mobile, it should be able to withstand vibrations, shocks or movement.

- The sensor may consist of a thermocouple (e.g. Type K, Type T), thermistor or platinum resistance device. All of these will provide an acceptable performance and cover a temperature range adequate for quick frozen foods.

- Systems are checked and calibrated during manufacture. It is important that once installed, periodic checks are carried out to ensure proper functioning. This is normally undertaken by checking against a calibrated thermometer placed in an equilibrated ice bath.

2.2 Air temperature monitoring of cold stores

Sensors should be placed high up, in relevant locations within the cold store, away from all positions causing uncontrolled temperature fluctuations such as cooler fans, the entrance or the exit (if different from the entrance) in order to enable precise recording. The position of the sensors should be chosen taking into account the cold air circulation and in such a manner to give an accurate recording of the temperature conditions. Recorders are recommended to be placed outside the cold stores in a convenient location selected for this purpose.

As far as the number of sensors concerned, each food business operator should evaluate its processes and make a documented decision on the number of sensors required. As indicative figures, small cold stores (less than 500 m^3) may need only one sensor, those with a volume of less than 30,000 m^3 may require two sensors, those with a volume from 30,000 m^3- 60,000 m^3 may require four sensors, and those with a volume greater than 60,000 m^3 may require 6 sensors. Retail stores with a volume less than 10 m^3 can be equipped with only a visible thermometer.

2.3 Air temperature monitoring during transport

Measurement of the return air temperature to the cooling unit will give a good indication of the load temperature, provided adequate air flow is achieved throughout the length of the vehicle.

In long vehicles (above 6 m), air ducting is recommended to ensure that sufficient cold air reaches the rear of the vehicle. Two sensors are recommended to be fitted in the compartment: one measures the return air temperature, and the other is placed two thirds to three quarters the length of the vehicle mounted in the ceiling ducts. The difference between these two temperatures should be an indication of how well the refrigeration is functioning. If the difference is large or variable it may indicate insufficient pre-cooling, incorrect stowage of pallets, or unnecessary delay in closing the doors.

The recorder can be placed in the vehicle cabin or mounted on the outside, usually near the refrigeration controls.

2.4 Air temperature monitoring in display cabinets

Display cabinets should be equipped with an accurate thermometer or temperature measuring device that is easily readable. In open cabinets, the temperature should be measured in the return air, at the load line level, or at the warmest place.

3. Product temperature monitoring

3.1 Direct temperature measurement

3.1.1 Specification of Measuring System

The temperature measuring device used to measure product temperature should be of better accuracy than that used for air temperature monitoring. The following specifications are recommended for the system, i.e. sensor and read-out:

- the system should have an accuracy of ± 0.5°C within the measuring range -20°C to +30°C;
- the response time should achieve 90% of the difference between initial and final readings within three minutes;
- the display resolution of the read-out should be 0.1°C;
- the measuring accuracy should not change by more than 0.3°C during operation in the ambient range -20°C to +30°C;
- the system should be calibrated or otherwise verified prior to use and at specified intervals against measurement standards traceable to international or national measurement standards;
- the accuracy of the system should be checked at regular intervals;

- the system should be robust and the device and equipment should be shock-proof; and
- the electrical components of the system should be protected against undesirable effects due to condensation of moisture.

3.1.2 Pre-cooling of the Probe

The probe should be pre-cooled to a temperature as close to the product temperature as possible before measurement. After inserting the probe, the temperature should be read when it has reached a stable value.

3.1.3 Non-destructive Temperature Measurement

Non-destructive testing is rapid and can be done without unduly disturbing the load. However, because the outside temperature of the package or carton is being measured this may result in up to 2°C difference between the true product temperature and the reading obtained.

Product surface temperature measurement undertaken non-destructively should:

- measure the temperature between cases on a pallet or between packages inside a carton;
- use sufficient pressure to give good thermal contact, and sufficient length of probe inserted to minimize conductivity errors; and
- use a probe with a flat surface to give good surface thermal contact, low thermal mass, and high thermal conductivity.

3.1.4 Destructive Temperature Measurement

Temperature probes are not designed to penetrate quick frozen foods. Therefore it is necessary to make a hole in the product in which to insert the probe. The hole is made by using a pre-cooled sharp pointed metallic device such as an ice punch, hand drill or an auger. The diameter of the hole should provide a close fit to that of the probe. The depth to which the probe is inserted will depend on the type of product:

- where product dimensions allow, insert the probe to a minimum depth of 2.5 cm from the surface of the product.
- where this is not possible because of the size of the product, the probe should be inserted to a minimum depth from the surface of 3 or 4 times the diameter of the probe.

- where it is not possible or practical to make a hole in certain foods because of their size or composition, e.g. diced vegetables, the internal temperature of the food package should be determined by insertion of a suitable sharp-stemmed probe to the center of the package to measure the temperature in contact with the food.
- in order to measure the centre temperature in large products after the quick freezing process it may be necessary to insert the probe to a depth of more than 2.5 cm.

3.2 SAMPLING OF PRODUCTS FOR TEMPERATURE MEASUREMENT

3.2.1 During Transport

A non-destructive temperature measurement should be taken of the product being loaded into the vehicle and a record entered in the documents.

A destructive product temperature measurement should be made if there appears to be a problem. If it is necessary to measure product temperatures during transport while the vehicle is loaded, samples should be selected from the top and bottom of the consignment adjacent to the opening edge of each door or pair of doors (see Figure 1).

If product temperature measurement is necessary, after the vehicle is unloaded and the cargo placed in a properly cooled environment, four samples should be selected from within the transport vehicle from among the following points, carefully noting the location of the load within the transport vehicle (see Figure 2).

When samples are selected, a non-destructive temperature measurement should in general be carried out first before deciding whether a destructive measurement should be carried out. A total tolerance of 2.8°C should be applied (2°C for limitations of methodology and 0.8°C tolerance for the system). If a destructive measurement is carried out, the tolerance of 2.8°C is not applicable.

3.2.2 At Retail

If it is necessary to measure the temperature of quick frozen foods in retail display cabinets, one sample should be selected from each of three locations representative of the warmest points in the cabinets. The positions will vary with the different types of retail display cabinets used.

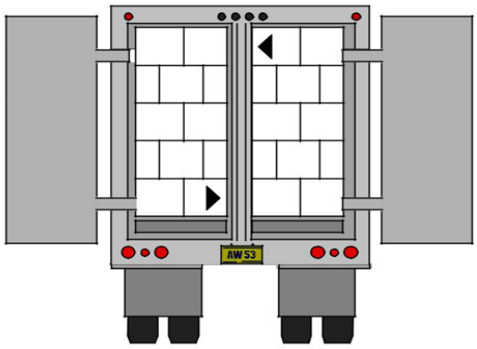


Figure 1 - Sampling positions for a loaded vehicle (◀)

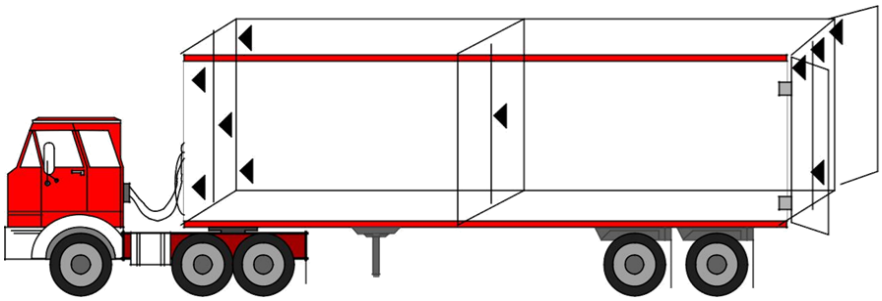


Figure 2 - Sampling positions for an unloaded vehicle (◀)

- o top and bottom of the consignment adjacent to the opening edge of the doors;
- o top and far corners of the consignment (as far from the refrigeration unit as possible);
- o centre of the consignment;
- o centre ofthe front surface of the consignment (as close to the refrigeration unit as possible);
- o top and bottom corners of the front surface of the consignment (as close as possible to the air return inlet).

4. Optional Approaches to Temperature Monitoring: Indirect Temperature Measurement

4.1 Simulated product

When air temperature monitoring is difficult, e.g. during the freezing process, it is possible to use a simulated food sample. This is a device that has a similar shape and is made of a material that has similar thermal properties and gives a similar cooling factor to the food being monitored. Materials such as nylon, polystyrene, polyvinyl chloride, perspex and polytetrafluorethylene have thermal properties similar to certain foods. Sensors can be embedded permanently into such a device and it can be packed along with the food packages and measured when required. The simulant may also be incorporated into a temperature recording device.

4.2 Recorders between packages

Small temperature recorders may be placed between packages or in a load, e.g. in cartons, in order to record the temperature over long periods. Such recorders may be programmed and the measurements retrieved by means of computerized devices.

4.3 Non-contact thermometers

These devices measure the temperature of the food by sensing the infrared radiation emitted by the food. The amount of radiation varies with different materials, which absorb and reflect and transmit radiation differently. Infrared thermometers can be portable and are usually “pistol shaped” sometimes with a laser sighting aid. Target size can be important, since the instrument averages all the radiation in its field of vision. Care must be taken in interpreting results from these devices with quick frozen foods because a package rapidly picks up radiation from its surroundings, there can be a difference between surface temperature and interior temperature. In addition the type of packaging will affect the radiation. Laminated foil packaging in particular can give large errors because it reflects radiation more efficiently than cardboard. Also available are devices which compensate for this type of error and measure the radiation through a window.

Fixed video camera-type infrared thermometers are also used. These can give thermal images, which permit industrial control of heating or cooling processes to ensure even processing. This is also true of the freezing process. Therefore it is possible to scan large numbers of products and pick out “hot-spots”, followed up by more accurate temperature measurements.

4.4 Temperature Indicators (TIs) and Time-Temperature Indicators (TTIs)

These devices give a colour change, either when a specific temperature has been exceeded (TIs), or when the integrated exposure to a temperature over a period of time has been exceeded (TTIs). There has been a reluctance to use TIs and TTIs on retail packages for a number of reasons, in particular because of their current limitations and because they are on the surface of packages and not inside the package, and because of their possible conflict with durability dates. However, TIs and TTIs may be used on the outside of cartons or pallets to detect temperature abuse during distribution from cold stores to holding stores at retail, and they can monitor transfer of quick frozen foods where monitoring records may not be available.

5 References

Codex Alimentarius Commission. *Code of Hygienic Practice for Processing and Handling of Quick Frozen Foods* (CAC/GL 8:1976 amended 2008).