

A Practical Guide to The Cold Chain From Factory to Consumer

Editor: R L Fuller

Concerted Action CT96-1180

Report 1



April 1998

A Practical Guide to The Cold Chain From Factory to Consumer

CONTENTS

Introduction	2
A Leighton J Sainsbury PLC, Stamford House, Stamford Street, London, SE1 9LL, UK.	
Handling Frozen Foods	4
R Gormley Teagasc, The National Food Centre, Dunsinea, Castleknock, Dublin 15, Ireland.	
Cold Store: Equipment and Maintenance	6
R L Fuller Cross Hill Cottage, Upper Harlestone, Northampton NN7 4EL, UK	
Transporting Frozen Food by Road or Rail: Preservation, Quality and Safety	8
G G Gucreata Carbors Metalicos SA, Aragon 300, 08009 Barcelona, Spain	
Retail Display: Equipment and Maintenance	10
F Polonara, ¹ G Cortella ² and P Schiesaro ³ ¹ Dipartimento di Energetica, Universita` di Ancona, Italy ² Dipartimento di Energetica e Macchine, Universita` degli Studi di Udine ³ Arneg Spa R & D Laboratory, Via Venezia 58 35010 Campo S Martino, Italy	
Guidance for the Home User	14
A Gigiel Food Refrigeration and Process Engineering Centre, University of Bristol, Churchill Building, Langford, Bristol BS18 7DY. UK	
Temperature Monitoring Equipment	16
M Minossi AEA srl, 60030 Angeli di Rosora An Italy, Via Fiume 16, Italy	
Temperature Monitoring Methods	18
E Derens Cemagref, BP121, 92185 Antony Cedex, France	
References	21

INTRODUCTION

Delivering and maintaining safe, quality, frozen foods is the responsibility of all individuals and organisations involved throughout the “Cold Chain”.

Effective management of the Cold Chain is only possible if everyone involved understands their role and the standards that should be applied. Rather like a “relay race” everybody needs to play their part, success relies on team effort.

This guide is intended for all people working with frozen foods, but is particularly suitable for small and medium sized enterprises. Its purpose is to explain, in simple, easy to understand terms, how enterprises can maintain the safety and quality of frozen foods for the benefit of both their own business and their customer. The guide identifies a number of common faults that can occur throughout the cold chain and offers simple practical solutions and controls. It follows the sequence of food from factory to the consumer.

As a guide it cannot, nor is it intended to, replace Government or European Union Legislation which must always be followed.

Some Questions

What is the “Cold Chain”?

The part of the Food Industry which deals with the transport, storage, distribution and selling of frozen food. It includes equipment and the operation of that equipment to maintain frozen food in a fully frozen condition at the correct temperature.

What is Frozen Food?

A Food which has been subjected to a freezing process specially designed to preserve the wholesomeness and quality of the product.

What is Quick Frozen Food?

Food selected in peak condition and freshness then preserved by rapid freezing.

Frozen food is normally kept colder than -18°C (or other temperature where this is specified on the packaging).

What are the benefits of freezing?

Freezing foods can preserve them in a good condition, as acceptable to the customer as the fresh product, for long periods. The process restrains the bacteria responsible for spoilage at ambient temperatures. It also slows the complex biological reactions that cause deterioration in fresh food.

Why is correct cold chain temperature important?

Food freezes at different temperatures, often below 0° C.

Any increase in the temperature of the environment in which the product is held, above –18° C, will have an adverse effect on the temperature of the product. After being held for only a few minutes in warmer air the product will start to thaw even though the product may still appear frozen. When it is again subjected to the correct environment temperature the product will only freeze slowly because the equipment in the Cold Chain is designed to **maintain** product at –18° C and not **freeze** product down to –18° C.

Slow freezing creates large ice crystals, which may damage the food structure and cause deterioration in Product Quality. Examples of affected product are:

- Grittiness in ice cream
- Clumping of vegetables and prawns
- Mushy, poor texture soft fruit

How to improve the quality of frozen food

Follow this guide through the various food handling stages.

HANDLING FROZEN FOODS

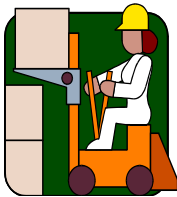
Temperature Abuse

Temperature abuse of frozen food occurs when it is allowed to warm up or when its temperature fluctuates. This becomes serious from a food safety and microbiological point of view when the product is inadvertently thawed. Remember food freezes at temperatures below 0° C depending on its ingredients. Temperature abuse below the freezing point could adversely affect sensory and nutritive quality. It occurs when frozen products are held at “too high a frozen temperature” or when the “frozen temperature” is allowed to fluctuate. The requirement, therefore is for a steady and suitably cold (product dependant) product temperature.

Temperature Control

Increasingly good temperature control is being achieved in the various sections of the frozen food chain due to improved equipment design, quality control, and by a heightened operator awareness of the importance of temperature control. However, there is no room for complacency and attention to temperature monitoring should be an integral part of total quality management programmes.

Transfer Points



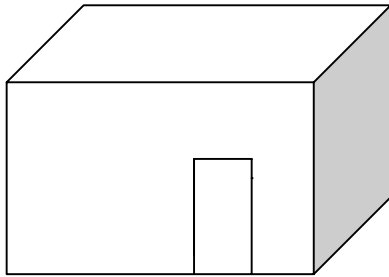
Transfer points are well known problem areas for temperature abuse and refer to points in the cold chain where products are transferred from one cold area to another, e.g. blast freezer to cold store, factory cold store to truck, truck to supermarket, supermarket cold store to display cabinets, and display cabinets to home. Frequent or prolonged door opening in vehicles during distribution and delivery is a major cause of temperature abuse. The transfer points normally involve a change of personnel and there can be periods when nobody has responsibility for the product, i.e. it may be left standing in a non-refrigerated area for considerable periods.

Preventative Action

- Food companies must realise that **transfer points** are potential temperature abuse areas for their products.
- The number of **transfer points** for a given product should be identified and current practices evaluated.
- The **relay system** (as in a relay race) should be introduced where the “baton” (in this case the food product) is transferred safely from one responsible person to another. The dropping of the baton or a slow hand over means a potential temperature abuse. A signing system should be introduced where the product is signed over from person to person, including monitoring and recording the product temperature.

- The **personnel** in the “relay race” must be identified and trained to ensure a fast and secure product hand over from cold area to cold area. Particular attention must be taken when new personnel are introduced.
- **Time-temperature indicators** (sachet type) should be attached to some of the product outer (packaging) in every shipment.
- A **logging/reporting** system should be introduced to ensure that all temperature abuses are reported to both ends of the commercial food chain, i.e. the processor and the retailer, to ensure that appropriate action can be taken where necessary.

COLD STORE: EQUIPMENT AND MAINTENANCE



The cold store is an enclosed chamber or box made of insulated walls, ceiling and floor and fitted with an insulated door. It is kept at a preset temperature by refrigeration machinery.

First Priority Points to Consider

- The size of the chamber.
- The temperature required.
- Whether or not the store **maintains** or **lowers** food temperature.
- The temperature of its surroundings.

Detailed Matters

The following requirements can be used as a check list to ensure a long life of the Cold Store and safety for personnel:

- Moisture vapour barrier – placed on the **outside** of all surfaces including the underfloor with all joints lapped and sealed. Any damage **must** be repaired.
- Underfloor heating is commonly used to prevent freezing of the foundations; usually this is by means of low voltage electricity or a recirculating fluid in pipework. This **must** be maintained if major damage is to be prevented.
- Low voltage heating around the door seal above and below the floor level will prevent ice forming which would otherwise interfere with door opening, typically operating at 2 - 5° C.
- An emergency exit from within the chamber to allow a safe escape route for persons trapped inside.
- Internal lighting – consider low temperature grade fluorescent lights.
- In regard to the refrigerating machinery, if the cold store is to cool the incoming food, what is the maximum temperature, weight and type of food being entered in a given period, e.g. an eight-hour period? Additional refrigeration capacity may be required to cater for the extra load.

Maintenance



Careful stock rotation and safe stacking are vital within the Cold Store. First in, first out is the best practice for food product storage.

As a Cold Store uses circulating air to carry the refrigeration energy to the foodstuff it is vital to leave space between the pallets and walls to keep even temperatures throughout the products.

Cold stores also work better, with less temperature variation, when they are well stocked.

Safe, secure stacking and good housekeeping show effective and efficient store use with less opportunity for forgotten or overlooked out-of-date stock. Emergency exit doors and routes must be kept clear.

Product temperature should be measured and recorded on its arrival at the store and the room temperature continuously monitored. This allows corrective action to be taken quickly if a breakdown occurs.

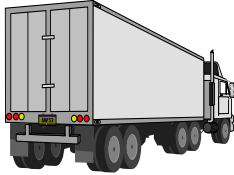
Doors should be kept closed, open only for access and closed as quickly as possible. If ice builds up around the doors the door heaters have failed and need attention.

Good lighting is important, faulty fittings should be repaired.

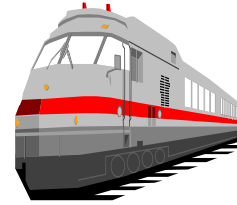


The refrigeration machinery should be maintained regularly. Computerised monitoring is available that can alert engineers automatically day or night if problems are imminent. If a breakdown does occur the store doors should be shut, locked promptly and temperatures observed from outside while repairs are completed.

TRANSPORTING FROZEN FOOD BY ROAD OR RAIL: PRESERVATION, QUALITY AND SAFETY



“The quality of frozen food can be as good or better than the quality of fresh food”



The achievement of this statement depends mainly on three points:

- That the **quality** of the product to be frozen is of good standard.
- The optimum freezing method is being used.
- The temperature of the product frozen is maintained (below -18°C) **all through the distribution chain.**

The vehicle must be provided with a good refrigerated system that remains operating at all times during transportation to keep the product temperature at the required values. During use it is important to keep doors closed, otherwise large quantities of warm air will enter the cold area. Warm air carries moisture that can badly affect the cooling performance

Careful attention to delivery routes and the pattern of unloading will help conserve the low temperature environment. The driver`s responsibility for the load includes responsibility for the vehicle`s temperature; close packing the vehicle will also aid conserve the product temperature. Training may be helpful.

Whilst the vehicle is standing in the depot electric plug in points to operate the cooling systems are a useful method of maintaining temperatures quietly without auxiliary diesel engines running.

If a pallet of packaged food is left standing in higher temperatures conditions, those packets at the corners or top edge are especially vulnerable to warming and will thaw quickly.

The enemy of all refrigerated transport systems is **heat**; this will affect the temperature and therefore reduce the **quality** of the frozen product, which is precisely what we have to avoid. Heat can enter the transport vehicle and the food product in two different ways:

- Through the vehicle insulation – possibly from sunrays.
- Through the air that leaks through badly sealed doors or worse, ingress of water

How to avoid this heat infiltration

- Choose a good insulating material (i.e. a poor heat conductor) and at optimal thickness to minimise the transmission of heat into the interior.

- Construct the body with the best seals possible to reduce hot air ingress.
- Paint vehicles a light colour, preferably white, to reflect the sun`s rays and keep them clean.

By fulfilling these conditions and choosing a good refrigeration system it should be possible to achieve a good quality, healthy and safe frozen food product, similar to fresh food.

RETAIL DISPLAY: EQUIPMENT AND MAINTENANCE

Introduction

Display cabinets are the link in the cold chain where frozen foods are displayed to the consumer. They are intended to be used for displaying and selling frozen foods and not for lowering product temperature. The refrigeration unit fitted in each cabinet is required to match the heat gain, mostly due to radiated heat transferred from the store and air infiltration. Several types of cabinet are used, the most common being:

- Vertical multi deck with or without glass doors, using refrigerated air circulated by fans throughout the cabinet. Shown in figure 1.
- Open top cabinets, which cool the food compartment using forced air circulation and/or natural convection. Two types are shown in figures 2 and 3.

In the case of vertical cabinets, heat gains are mostly due to air infiltration, whereas in open top cabinets radiative heat transfer from surroundings becomes predominant. European Standard EN441 classifies display cabinets also in terms of temperature tolerance. The class for quick frozen food is L1, with a food storage temperature of -18°C and a tolerance to -15°C for short periods. Note that to maintain -18°C in the food, much lower temperatures are necessary in the refrigerating machinery; typically -38°C depending on the cabinet design and the emissivity of the food packaging.

Components

A display cabinet consists of a thermally insulated body enclosing the load volume and the cooling equipment. The refrigeration unit may be totally within the cabinet (integral cabinet) or could be partially situated in a remote location. In this case only the heat-exchanging coil and fans are within the cabinet and the remote refrigeration unit supplies the cooling fluid. In either type frost will form on the cooling coils and air ducts which need cyclical defrost.

Installation

Cabinets must be installed to the maker's instructions into positions, which are within suitable climate conditions. Cabinets are certified by the manufacturer to comply with EN441 for a specific "climatic class". The required cabinet performance will only be achieved if the ambient conditions are cooler and less humid than limits specified for the climatic class shown on the nameplate.

The climatic classes according to EN441 standard are:

Climatic Class	Dry Bulb Temperature $^{\circ}\text{C}$	Relative Humidity %	Dew Point $^{\circ}\text{C}$
1	16	80	12
2	22	65	13
3	25	60	17
4	30	55	20
5	40	40	24
6	27	70	21

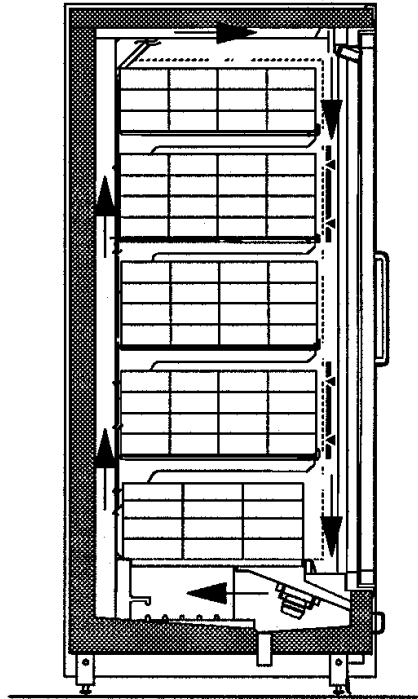


Fig. 1 – Vertical multi-deck cabinet with glass door

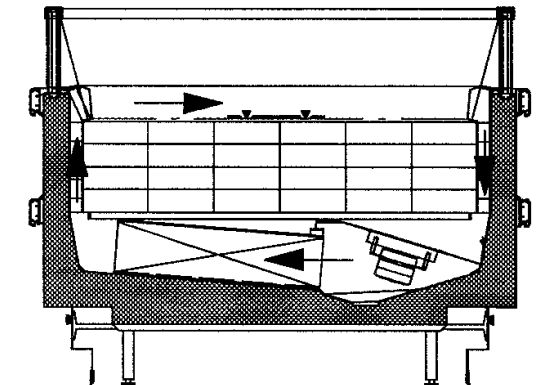


Fig. 2 – Open top cabinet with forced air circulation

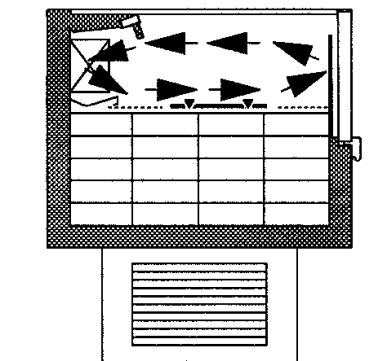


Fig. 3 – Open top cabinet with natural convection

If these conditions cannot be guaranteed, air conditioning is advisable. In any case, direct exposure to sunlight and to draughts (air diffusers, doors, and windows) must be avoided. The maximum air velocity allowable in the proximity of the cabinet is 0.2m/s. Integral refrigerated cabinets must have adequate room and sufficiently cool surroundings in which to dissipate the condenser heat. If excessive radiative heat transfer to the load is encountered, reflective screens made of low emissivity material should be installed above the cabinet taking care to leave customers access.

Loading

Product must be loaded into the cabinet following the maker's instructions and within the load limit lines, which are marked on the cabinet. Products outside the limit line will not be kept at the correct temperature, and will disturb air circulation, warming all the food.

It is important that food placed in the cabinet is already at -18°C or below. Price labelling must not interfere with the designed air flows in the cabinet. The use of reflective packaging is recommended to avoid excessive radiative heating.

Operation

Open display cabinets should have night covers applied when the store is closed. All refrigeration coils need periodic defrosting, performed as recommended by the cabinet manufacturers and checked at regular intervals.

During defrost the cabinet temperature will increase, due to the operation of defrost heater(s). For this reason, excessive accumulation of frost should be avoided, frequent "little and often" defrost stages are preferable, undertaken when the store is closed and with the night covers in place.

Maintenance

Daily checks of the cabinet thermometer are essential as this will indicate any change from normal values, and faults must be repaired immediately to avoid risks of spoiled and wasted product.

Condensing coils should be cleaned of dust and debris every two months in order to keep the refrigerating unit performance at its best. The defrost water outlets must be kept clean and free running.

Periodic cleaning of the whole of the cabinet is a requirement of hygiene and safety regulations and a useful way of demonstrating efficiency to the customer.

A thorough check of the whole apparatus at least every two years is strongly recommended. This should include the integrity of the structure, correct operation of the thermodynamic cycle, control settings including defrost, and safety of the electrical components and connections.

Breakdown

Breakdown due to electrical supply or system failure requires immediate cessation of sales, closing the night covers, turning off fans and automatic defrosting devices.

If the breakdown time becomes extended the product must be removed and placed in back-up storage rooms. If temperature abuse is likely to have occurred to the food due to a prolonged breakdown the food manufacturer should be contacted and proper checks undertaken in order to ascertain if the goods are still saleable

GUIDANCE FOR THE HOME USER

Including taking the food home, storing it in a freezer and thawing it.



The secret is to buy the food frozen and keep it frozen until it is needed. Quality will be worse if food is bought fresh and frozen it at home. This is because:

- The freezing rate is very slow in domestic freezers and,
- Much of the storage life has been used up before the food is frozen.

Taking Frozen Food Home

When shopping for frozen food make sure it is the last shop visited and the last items collected before going to the check out. Wrap the food in an insulated bag or box, take the food straight home and unpack into the freezer – do not leave it in a hot car or exposed to sunshine.

Storing Frozen Food in the Home Freezer or Fridge

Food can be stored in one, two or three star equipment, as shown on the frozen food compartment. Three star equipment should be used for the storage of frozen food – this means that food will be stored at a temperature either at or colder than -18°C . Two star compartments store food at -12°C and one star compartments at -6°C . **At -6°C the temperature is too warm for the storage of frozen food more than a few days.**

Freezers may be upright with a door at the front or chest freezers with a lid on top. Upright freezers are more convenient to use. Chest freezers are cheaper to buy, cheaper to run and generally hold more frozen food

When buying a freezer make sure it will work in the position desired, possibly in a hot kitchen, in a built in unit, under a work surface or in an outbuilding which is cold in winter. Always seek advice. The storage temperature of the frozen food is more important than the size, shape, convenience, “add on gimmick” or price of the freezer. If it doesn't keep the food cold, it doesn't work and money will be wasted.

Freezer Use

Keep the door or lid closed. Only open it when required to load or remove something and close it immediately afterwards. Do not leave the door open when doing something else before returning to the freezer. If necessary open and close the door several times rather than leave the it open for a longer period.

Do not place unfrozen food adjacent to frozen food in the freezer. The frozen food will warm up and its quality will deteriorate. Place it in the fast freeze compartment until frozen.

Check that the freezer is working. Using a freezer thermometer will help – the liquid crystal types with different coloured members that become visible depending on the temperature are worthwhile. Positioned in the middle at the top part of a chest freezer or in the case of an upright freezer on the top shelf at the front. Check this temperature when first opening the door; it should be colder than -18°C .

Always read the instructions that come with the freezer and follow the manufacturers advice. The freezer may not work if it is used in a way that the maker does not recommend.

Home freezers need very little maintenance. Check that the temperature is always colder than -18°C (see above). Keep the door or lid seal clean. Keep the condenser, (the warm bit often at the back or side of the freezer), clean and unobstructed, and defrost internally when required (unless it is a frost-free type).

Thawing Frozen Food



If the food comes with instructions on thawing, follow the instructions. In general most frozen foods are cooked from frozen and this is safer. However, large items of food, particularly meat, need to be fully thawed before following cooking instructions for fresh (thawed) meat. Thawing can take a long time, particularly for large joints or poultry. Food is best thawed placed in the bottom of a refrigerator, not the freezing compartment, where the temperature should be approximately 5°C , and left there for a period of one day for normal size joints or two days for a large item. Check that the centre is fully thawed before cooking.

Thawing food by leaving it exposed in the kitchen is much faster than thawing it at the bottom of a fridge **but can be very dangerous**, particularly if the food is left out for longer than a few hours. This is because the bacteria on the surface of the food, which warms up more quickly than the centre, will inevitably grow very quickly. This leads to the contamination of the kitchen surfaces and utensils and, if the food is not properly cooked, of the person eating it. It is because of the risk of food poisoning that it is dangerous to thaw something twice. Therefore food that has been thawed should never be refrozen.

TEMPERATURE MONITORING EQUIPMENT

Temperature monitoring includes three different aspects.



- Temperature measurement
- Temperature display
- Temperature recording

Temperature of both the **food and its surroundings** should be monitored. It may be necessary to measure temperatures in many places; for instance, in a large batch of food, or if the conditions vary in a chamber or during transportation.

Two types of monitoring equipment predominate, either mechanical or electronic. The choice depends upon whether information is to be retained and if so whether a written or electronic record is required, and at what cost. Initially appropriate instrumentation should be selected; the following factors may affect the choice.

Comparing the two methods

	Mechanical	Electronic
For	Temperature data direct to paper	Electronic format of information Cheap, small Rugged construction is possible
Against	Expensive	Battery required

While portable or hand held thermometers (not glass) are ideal for instant readings they are not suitable for permanent recording and do not meet the legislative requirements.

Modern equipment uses a combination of methods, typically:

- Measurement & Display - Mechanical or Electronic
- Measurement & Recording - Predominately electronic
- Measurement, Display & Recording - Mechanical & Electronic

Having selected the desired method it is important to define the system in more detail, answering the questions listed over will help.

- What is the temperature range in the controlled and ambient areas?
- What accuracy is required?
- What shape of probe is required? A long flat probe to reach between packages?
- Is water proofing required?
- Will the system require calibration and at what frequency?
- If an electronic system is desired will it operate at the typical temperatures encountered?
- Is the battery life of an electronic system suitable for the application?
- If time and temperature data are required should this be immediately available? Is a paper print required or is electronic data necessary for further calculations? What legal requirements exist regarding frozen food transport or storage?
- How long is the recording to continue? What is the sampling period for electronic equipment or the time temperature recording speed for mechanical equipment?
- Will the equipment be subject to vibrations – for instance in transport vehicles?
- Can the data be used with both proprietary and commercial software?

It should now be possible to specify the monitoring equipment required.

Temperature and Time Temperature Indicators

Commonly known as TIs and TTIs they are devices which use a physio-chemical reaction to produce an irreversible indication of temperature or time temperature history to which they are applied.

They are commercially available, generally to monitor the conditions of the packaging, sometimes the food surface but not the food core temperature.

They are useful for packs in vulnerable positions such as the top corner locations of pallets of foodstuff. Care is required to ensure no conflict of “best before” date declarations on the food.

TEMPERATURE MONITORING METHODS



Operators need to determine whether the frozen food products are within the manufacturers stated temperature tolerances.

Temperatures can be measured **directly** using contact with the food or **indirectly** either by monitoring the continuing air temperature or measurements taken between adjacent packages. Only as a last resort should invasive tests be conducted as this will destroy the pack integrity and make the product unsaleable.

Stages of Investigations

- Inspect air temperature recorders and thermometers to ascertain the temperature history of the product.
- Visually check the product appearance, looking for signs of thawing which may include evidence of drip loss, ice on the inside of the pack, soiled packaging, etc.
- Undertake a non-destructive investigation by measuring the temperature between adjacent packages or boxes.
- If any of the above indicate temperatures have been too high then an invasive test inspection may be required. Reference should be made to the Frozen Food Processor for advice and the EU Directive 92/2/EEC if this is unavoidable.

Temperature Requirements

The Food Processor will state guidelines for the temperatures of the food throughout the shelf life of the product. It is important this guidance is followed and monitored throughout all stages of the distribution network, i.e. the Cold Chain.

Legislation demands certain temperature conditions that are shown in the European Directives 89/108/EEC Quick Frozen Food Directive and 92/1/EEC Monitoring of Quick Frozen Food Temperatures.

Stabilised food temperatures should be maintained at -18°C or colder, exceptions for brief periods are allowed during transportation or local distribution when -15°C is permitted. Also in a retail display cabinet temperatures should be at -18°C to an extent consistent with good storage practice but not warmer than -12°C .

Cold stores of under 10 m^3 capacity in retail outlets and retail display cabinets need only an clearly visible thermometer.

Directive 92/2/EEC describes the official procedures and method of analysis, including destructive inspection. Other “scientifically valid measures” are allowed subject to the user describing the method used.

Air Temperature

The recordings must be filed and kept at the site for at least one year, or longer if the food has a storage life labelling of over one year.

Within the equipment manufacturers operating manual, maintenance inspection periods will be stated, the inspection reports should be retained. An annual inspection undertaken by a qualified service provider is recommended for equipment that is difficult to access; again written records should be retained.

Cold Room

Air temperatures must be monitored and recorded (except for rooms smaller than 10 m³)

Probes should be located in the warmest part of the room which is likely to be near the door, or alternatively in the **return** air flow stream to the refrigeration evaporator. Both probes and the recording instruments must be suitable for the likely temperatures and positioned such that they are protected from harm yet easily accessible.

If the temperatures are outside the given tolerances automatic alarms should be activated. Devices are available to give audible, visual and /or automatic notification to engineers via modem and telephone links.

Transport

The user must verify that recorders

- Are suitable for transport.
- Have a suitable range of temperature (in operating conditions, at boundary conditions and in storage conditions).
- Are fixed securely.
- Are compatible with the washing processes within the enclosure or easily removable.

For each device, the following must be noted:

- The vehicle on which the recorder is placed must be identified.
- The measuring frequency must be verified.
- The date and time must be verified.

The temperature should preferably be measured in the return air to the cooler near the thermostat sensing bulb controlling the refrigeration unit. When C-class vehicles (as classified under the ATP regulations) are also used for transporting chilled food it is advisable to place a probe in the evaporator discharge airflow (to avoid freezing chilled food). The position of the probes should be indicated on the recordings.

Display Cabinets

European regulations for Quick Frozen Foods demand clearly visible thermometers in display cabinets.

- Placed to measure the cabinet air temperatures, which on open retail cabinets should be at the air return side at the level of the clearly marked maximum load line.
- Users should verify that the temperatures obtained conform to the data supplied by the manufacturer.

Monitoring systems give useful information when quick decisions are required if a mishap occurs.

Product Temperature

Visual Inspection

This method is used to detect the most serious anomaly, which is thawed product and requires no special equipment. It can also detect earlier temperature rises that were corrected before inspection. The condition of the packaging may indicate temperature abuse, for example the presence of drip marks, excessive icing, etc. Receiving agents should be trained to recognise such signs.

Contact Inspection

An approximation of the internal temperature of the product can be obtained by measuring the temperature between two layers of packages or boxes. An appropriate flat probe should be used.

- Such measurements should be undertaken with a pre-cooled probe offering good surface contact, low heat mass and high thermal conductivity.
- Sufficient pressure between the packs is needed for good surface contact. The probe should be inserted deeply enough to minimise errors from conductivity and to insert the sensitive part of the element completely.
- Wait for a steady, non-fluctuating, indication before reading the temperature.
- Measure the temperature at several points, using several probes or move one probe rapidly from one point to another.

References

European Directives

- 89/108/EEC Quick Frozen Food Directive
- 92/1/EEC Monitoring of Temperatures in the means of transport, warehousing and storage of quick-frozen foodstuffs for human consumption
- 92/2/EEC Official procedures and method of analysis-including destructive inspection.
- 93/43/EEC Hygiene of Foodstuffs

Official Standards

- EN 441 Refrigerated Display Cabinets parts 1 to 12.
- prEN 12380 Temperature Recorders for the Transport, Storage and Distribution of Chilled, Frozen, Deep Frozen / Quick Frozen Food and Ice Cream – Tests, Performance, Suitability

Code of Practice No 12 HMSO 1994

Quick Frozen Foodstuff Division of Enforcement
Responsibilities in Performance of Temperature Monitoring
and Temperature Measurements
ISBN 0 11 321 793 5

Commercial Publications

- “Guide to Refrigerated Transport” published by
International Institute of Refrigeration
ISBN 290 36 3372X price US\$ 46
- “Control of the Cold Chain for Quick Frozen Foods – A Handbook”
to be published shortly by
International Institute of Refrigeration.
- “A Food Industry Specification for Defining the Technical Standards and
Procedures for the Evaluation of Temperature and Time-Temperature Indicators”
Technical Manual No 35 published by
Campden & Chorleywood Food Research Association
- “Guide to the Storage & Handling of Frozen Food” (The gold book)
British Frozen Food Federation