

We measure it



**Tips and tricks  
for cold-chain-  
mandatory foods.**

# 1. The cold chain

## 1.1 From the producer to the consumer

When customers buy food, they expect as a matter of course that the products are of impeccable quality, and safe. In order that this really is the case, the cold chain is crucial for refrigeration-mandatory foods such as meat and sausage or dairy products. It ensures the quality and safety of foods: Legally prescribed temperature limit values may not be exceeded on the way from the producer to the consumer.

The reason for this are bacteria found on and in foods, which are potentially harmful to our health. Bacteria are not necessarily bad, some of them are even helpful to human beings. For example, bacteria are important for digestion, as they form the digestive gut flora in the large intestine. In food production too, bacteria are used intentionally. Milk, for example, is thickened and processed into yoghurt or sour milk cheese by adding lactic acid bacteria. However, some bacteria can cause illness or contribute to foods' spoiling more quickly. And if these are present on or in foods, this becomes a problem. Since bacteria reproduce faster the warmer their surroundings are, uninterrupted refrigeration is of crucial significance for fresh and deep-frozen foods. This prevents these foods from spoiling prematurely.

## 1.2 Quality and safety of products

The sale of qualitatively compromised or unsafe foods can result in serious damage to the image of the affected companies.

Product quality is a perceptible customer benefit, and awakens the desire to purchase the product again. It is moreover the duty of the food producer to protect the consumer from negative health influences or damage, and to guarantee the safety of foods. As the safety and quality of foods can be negatively influenced by the wrong temperature, the monitoring of the temperature of cold chain-mandatory products is a central building block in the assurance of the desired quality and marketability.

According to the regulation EC 178/2002, "marketability" means that foods are

- not damaging to health,
- suitable for consumption by humans and
- correctly labelled.

Qualitatively compromised products are, for example, those which are not spoiled and are still edible, but do not meet the required standard in terms of their appearance. This may be a lettuce which has become limp and no longer looks appetising to the purchaser.

Foods are no longer safe, for example, when they are spoiled. This can lead to nausea, diarrhoea etc. in the consumer.



### 1.3 Liability transfer

No foods may ever be brought into circulation which are damaging to health or unsuitable for consumption.

On the way from the raw material to the sales-ready goods, foods pass through different manufacturing levels and processes. This results in a chain of producers, processors and dealers. The question of responsibility in terms of liability arises in this chain: Who is liable in the event of damage?

According to the principle of due diligence, all food businesses carry the responsibility for fulfilling the requirements of the food safety laws themselves. One crucial legal obligation is the assurance of traceability. This must be guaranteed on each level of the entire food chain (from the producer to the consumer and vice versa). If the refrigeration of the product in production, storage, transport and/or sale is crucial to the quality or safety of the foods, it must be provable that the right temperature, i.e. the duty of refrigeration, has been adhered to.

### 1.4 The most important regulations

The adherence to the cold chain serves the quality and safety of foods. There are various ordinances, norms and standards with regard to the cold chain. They stipulate, among other things, that proof of temperature compliance is a mandatory requirement. In many countries food inspectors therefore check whether the temperature limits have been adhered to, and monitored and documented at regular intervals. If this is not the case, the market participants can be subject to penalties. This affects food businesses and smaller food dealers, kitchens and canteens, supermarkets or logistics companies.

#### EU directives on food safety

##### *EC 178/2002 Basic Directive Food Law*

The directive forms the basis for European food law, and applies to all those commercially involved with food. It contains principles and definitions of food law, with references to further guidelines and directives, and describes, among other things, the creation of EFSA (European Food Safety Authority) as well as the early warning system of the European Commission RASFF.

##### *EC 852/2004 Food hygiene*

The objective of the directive is to guarantee a high level of consumer protection through uniform stipulations on food hygiene, and to monitor these within the EU. The stipulations cover, among other things, the application of HACCP principles, documentation duty with regard to food hygiene, traceability as well as permits for and/or registration of businesses. It applies to all levels of the food chain, from the producer to the consumer. Two complementary directives contain specific stipulations for food products of animal origin (EC 853/2004) and their official monitoring (EC 854/2004).

##### *EC 882/2004 Regulation on official controls*

The directive establishes how official controls are to be conducted by the authorities in order to monitor the implementation of the food and animal feed legislation.

#### *EC 1935/2004 Food contact materials*

This directive applies to all objects which come into contact with food. In principle, no substances from the contact materials should be transferred to the food. If this is the case, the directive lays down stipulations.

#### Food safety standards

##### *IFS International Featured Standards*

The IFS family of standards initiated by the food distribution sector serves the uniform evaluation and qualification of own-brand manufacturers.

The IFS family covers the following standards:

- *IFS Food*: For food producers and/or companies which process or handle foods, and which package loose foods.
- *IFS Cash & Carry*: For large consumer and large distribution operations which deal in loose or packaged foods.
- *IFS Logistics*: For companies and service providers which handle foods logistically.
- *IFS Broker*: For trading companies which purchase goods for the purpose of re-sale, without necessarily coming into contact with them themselves.
- *IFS HPC (Household and Personal Care)*: For factories which process or handle household and personal care products.

##### *BRC Global Standard for Food Safety*

The BRC Global Standard was developed by the British Retail Consortium. It defines food safety requirements and can be applied wherever open foods are processed or packaged.

##### *GlobalGAP (Global Good Agricultural Practice)*

Quality standard for products from agriculture and market gardening (incl. seed and seedlings and well as compound animal feedstuffs).

##### *SQF (Safe Quality Food)*

SQF was developed for all areas of the food industry. The code is an HACCP management system which applies NACMCF and CODEX HACCP principles and guidelines, in order to reduce the occurrence of non-safe foods on the market.

##### *GRMS (Global Red Meat Standard)*

The GRMS standard contains special requirements for the slaughtering, cutting, deboning and handling processes of red meat and meat products.

#### Standards

##### *ISO 22000 Management system for food safety*

The norm serves the set-up of a management system for food safety. It is based on the ISO 9001, and additionally demands the introduction of an HACCP concept and the fulfilment of the requirements involved with this. The requirements are not as stringent as those of the private commercial standards and the FSSCs, however the norm is applicable for all food chain organizations worldwide.

##### *FSSC 22000 (Food Safety System Certification 22000)*

The FSSC 22000 completes the requirements of the ISO 22000 with those of the PAS 220/ISO 22002-1, and has the objective of guaranteeing food safety during production. It has been recognized by the Global Food Safety Initiative (GFSI) as an equivalent in a benchmark study with food safety standards. In contrast to the private commercial standards, the FSSC 22000 is based on an ISO norm, and is not the property of an interest representative group.

##### *DIN EN ISO 9001 Quality management systems*

The cross-sector norm contains requirements placed on the set-up of a quality management system, with the objective of continuously improving all business processes, fulfilling customer demands and adhering to legislative stipulations. This norm additionally makes extensive demands regarding measuring equipment.

*EN 12830*

This norm sets out all the technical and functional properties of measuring instruments for monitoring and recording air temperature in storage, transportation and distribution facilities for refrigerated, frozen, or deep frozen foods and ice cream.

*EN 13485*

This norm defines the requirements thermometers are to fulfil for use in the food processing sector. The requirements include reference to the method of measurement (contact/ penetration measurement), the measuring range, measuring accuracy and the measuring instrument resolution.

*EN 13486*

Test regulations for thermometers and temperature recording devices are dealt with here. This standard also includes a description of the testing process, environmental testing conditions and requirements of the working standard.

**1.5 HACCP**

HACCP (Hazard Analysis and Critical Control Points) is an instrument which helps food businesses to achieve a higher level of food safety. It was developed in 1959, commissioned by the US space

authority NASA. They required 100 % safe foods to feed their astronauts in space.

HACCP is described in the Codex Alimentarius, and its objective is safe food production and consumer protection. It is binding for food producers, and is required by, among others, the hygiene directive EC 852/2004 as well as the food safety standards (GFSI-Standards (BRC, FSSC 22000, GlobalGAP, IFS-Food, SQF), ISO 22000).

The first step in an HACCP analysis is the examination of the entire process and its evaluation with regard to four hazards (microbiological, chemical, physical, allergenic). For the cold chain it is the microbiological hazard which is significant. If a process step is critical, control points (CCPs) and suitable limit values are established. The monitoring of the control points must be recorded. If deviations are found to have occurred, previously defined correction measures must be initiated.

An HACCP analysis thus determines where and when which temperatures (over and above the legal requirements) must be maintained and specifically monitored, in order to prevent danger to the consumer.



**FSMA (Food Safety Modernization Act)**

The Food Safety Modernization Act of the US Food and Drug Administration (FDA) is one of the most important food safety law reforms in the USA. It came into effect in 2011. The objective of the FSMA is to secure the food supply in the USA by shifting the focus away from reaction to, towards prevention of, contamination. This is achieved by, among other things, the binding introduction of the HACCP concept, and by placing more responsibility on importers.

**For example:**

- Legal stipulation for fresh poultry: max. +4 °C
- Risk determined in hazard analysis: Poultry can be too warm in Incoming Goods.
- Monitoring of control point: Here the temperature must be monitored in order to initiate measures in cases of deviation.

## 2. To measure is to know

### 2.1 Spot check measurement or continuous recording?

In the monitoring of temperatures, we differentiate between two types of testing:

1. Spot check measurement with portable temperature measuring instruments. These are either purely measuring instruments (i.e. they only display the measurement value), or storage thermometers. These save the measured data in an internal memory or transfer them by wireless LAN to a data store, for example in the Cloud.
2. Continuous data recording in which a measuring instrument with a memory remains with the goods (or in their proximity, e.g. in a refrigerated room), and records values at regular measurement intervals, and saves them – in an internal memory and/or online in the Cloud.

### 2.2 Portable, hand-held measuring instruments

Portable temperature measuring instruments are available in different designs and with different probes.

1. Instruments with a permanently fixed probe are suitable when the measurement task to be done is always the same, e.g. penetration measurement in foods. (Fig. 1)

Examples:

- Core temperature of dairy products,
- Fish in a refrigerated display



Fig. 1: Measuring instrument with fixed probe



Fig. 2: Measuring instrument with folding measurement tip



Fig. 3: Measuring instrument with exchangeable probes

A established design is the folding thermometer in which the measurement tip is directly attached to the instrument and can be folded away to save space. (Fig. 2)

2. Instruments with exchangeable probes are especially suitable when varying measurement tasks are required. (Fig. 3)

Examples:

- Measurement of air temperature in a refrigerated room with an air probe
- Measurement of the core temperature of refrigerated meat
- Measurement between deep-frozen packaging in Incoming Goods

#### Important:

In the food sector, the instruments and especially the connection between probe and instrument must be waterproof. Recommended protection class: IP65 or IP66. This is required by the norm EN 13485, for example.

### 2.2.1 Non-contact measurement

Some instruments measure the temperature without direct contact to the foods: Infrared measuring instruments.

They are suitable for obtaining a rapid overview of the temperature of the products. So-called non-destructive measurement enables the temperature to be determined without the instrument coming into contact with the product.

Infrared thermometers measure only the surface temperature. This is an advantage with packaged products. Here only the outside of the packaging is actually measured, but not the product itself, because infrared thermometers cannot "see through" the packaging.

How reliable the measurement result is depends to a great extent on the surface and the packaging of the goods. This can lead to measuring inaccuracies.

### 2.3 Data loggers

Data loggers are instruments for continuous data recording, which store measured data in an internal memory or send them wirelessly to a storage unit. (Fig. 4)

Here too, there are two possibilities:

1. Data loggers accompany the goods, and are placed in the direct vicinity of the products. They have direct contact with the goods, for instance in the outer package or between individual packaging.
2. In the "semi-stationary" method, the data logger is attached to the side of the vehicle or the transport box, and measures either the air temperature via the built-in probe, or the product temperature with the help of an external probe. Data loggers for refrigerated and deep-frozen foods must comply with the norm EN 12830.



Fig. 4: Monitoring refrigerated rooms with data loggers

### 3. How to measure?

A very precise measurement is a core temperature measurement, i.e. a penetration probe measures the temperature in the interior of the refrigerated goods. However, for many products, this means destroying the packaging and the product.

In order to avoid this, a 3-level process has proven its worth in practice:

1. First of all, an infrared measuring instrument is used to scan the surface, e.g. of yoghurt pots. Infrared measuring instruments are suitable for obtaining a rapid overview of the temperature of the products. If the temperature is clearly within an acceptable range, the test is finished.
2. Is the temperature of some products outside the prescribed range?  
Then a contact probe is inserted between two products, and the temperature measured there.  
If the temperature is now within the limit values, then the previous infrared measurement showed merely a warming of the outside. (Fig. 6)
3. Is the temperature still outside the prescribed range?  
Then for verification purposes, a penetration measurement is carried out on one or more pots. The probe is inserted into the foodstuff, and measures the core temperature. (Fig. 7)



Fig. 5: Non-contact measurement



Fig. 6: Between packages



Fig. 7: Penetration measurement

## 4. Where does measurement take place?

### 4.1 Product manufacture and storage

Fresh and frozen goods whose preservation and quality are dependent on permanent refrigeration require an uninterrupted cold chain in order to protect them from spoiling for as long as possible.

For refrigeration-mandatory foods, legal stipulations regulate the temperature zones which must be adhered to during the cold chain.

- Deep-frozen meat and fish need to be continuously chilled through to minus 18 °C.
- For fresh meat a maximum temperature of +4 °C must be guaranteed, for milk and dairy products +8 °C.
- For fruit and vegetables, a temperature range (depending on the type) of +1 to +12 °C is applicable.

### 4.2 Food transport

Here the focus is on the transfer of liability.

For the purposes of traceability, the freight forwarder must be able to prove that the cold chain was not interrupted during transport.

Measurements carried out during transportation call for special data logger requirements:

- Limited package space necessitates a flat design
- Easy to use
- The logger should only record transport-relevant data
- Alarms must be easy to recognize, in order to initiate control measures in time.



Fig. 8: Measurement in food transport

### 4.3 Incoming Goods

Incoming Goods is the location at which foods are delivered.

In the context of food safety, fresh food and frozen goods deserve special attention here, because adherence to the cold chain is prescribed for them.

Different temperature ranges apply for each of these product groups (according to DIN 10508):

- Deep-frozen foods:  $-18\text{ }^{\circ}\text{C}$
- Minced meat:  $+2\text{ }^{\circ}\text{C}$
- Fresh fish (in ice):  $+2\text{ }^{\circ}\text{C}$
- Fresh poultry:  $+4\text{ }^{\circ}\text{C}$
- Processed fish (marinated, soured and smoked):  $+7\text{ }^{\circ}\text{C}$
- Other perishable foods, including e.g. baked goods with incompletely baked filling or covering, freshly cut salads and delicatessen salads:  $+7\text{ }^{\circ}\text{C}$
- Pasteurized milk:  $+8\text{ }^{\circ}\text{C}$
- Butter, cream cheese, soft cheese:  $+10\text{ }^{\circ}\text{C}$

The handover of goods generally takes place in the loading bay. Immediately after the supplier's arrival, the temperature is measured here either on the loading platform or directly in the truck.

Non-contact infrared measurement is used especially often, as it is non-intrusive and fast. Measured values are entered into a test form (manual documentation), or recorded on a PC.

If data loggers have been used for continuous temperature recording, the data are read out here, or transmitted wirelessly to the base station. A printed report provides proof.



Fig. 9: Measurement in Incoming Goods

### 4.4 Refrigerated counters, shelves etc.

In sales outlets, products in need of cooling are stored either in refrigerated units (shelving, displays, counters) or in deep-freezers.

Refrigerated products:

The temperature of sealed products is usually measured without contact. For meat, sausage and cheese, a penetration measurement is normally carried out. The permitted temperature range here is typically between  $+2$  and  $+10\text{ }^{\circ}\text{C}$ .

Deep-frozen products:

Non-contact measurement or measurement "between packages". The permitted temperature range here is typically between  $-20$  and  $-18\text{ }^{\circ}\text{C}$ .

Refrigerated shelving, counters:

Data loggers are installed in refrigerated shelves or counters close to the air intake, as the air temperature is warmest here (should still be under  $+10\text{ }^{\circ}\text{C}$ ). In deep-freeze units, a measurement is taken ideally between the packaging (e.g. spinach, pizza, ice cream).

Refrigeration and deep-freeze rooms are usually monitored using the "semi-stationary" method, i.e. a data logger is fixed to a wall of the refrigerated room, where it measures and records the air temperature.



Fig. 10: Measurement in refrigerated shelving



Fig. 11: Measurement in a refrigerated display

## 5. Summary

- Refrigeration prolongs the lifetime of foods and hinders germ growth.
- HACCP describes the implementation of process-oriented hazard analyses. Where risks occur, control points must be set-up and correction measures defined.
- What is not documented does not exist. For this reason, write down the measured values or store on a PC.
- Handheld measuring instruments for mobile measurements "in passing", data loggers and storage systems as transport escorts, or "semi-stationary".
- Non-contact measuring instruments measure quickly, easily and without damaging the packaging. But they only measure the surface. In case of doubt, carry out a measurement "between the packaging" or a penetration measurement (contact measurement).

