Chapter 38

Frozen Fish

According to the UN's Food and Agriculture Organization, there are more than 28 million people engaged in fishing operations worldwide. The annual world catch of fish exceeds 100 million tonnes, of which around 25% is processed into frozen fishery products. Each year, a high proportion of these frozen products enters international trade and is carried by sea.

Cargoes of frozen products are sometimes found to be damaged when they are unloaded from ships, leading to rejection and to claims against shipowners and agents alleging that the damage is due to negligence on the part of the Master and crew of the carrying vessel.

A vessel is not liable for damage that was sustained before loading, or during handling if due to the actions of third parties. However, it is often difficult to establish the precise cause and chain of events leading up to the damage and specialised knowledge is required to sample and inspect fishery products and relate their condition to the events of the voyage. However, vessel operators also need adequate technical knowledge to minimise the risk of problems occurring and to act in the event of a claim.

38.1 Frozen Fishery Products

A variety of frozen fishery products are carried by sea in reefer vessels and reefer containers. The main types, in approximately descending order of frequency, are:

Whole, gutted[1] or dressed[2] fish, individually frozen

Tuna intended for canning is a typical example.

Figure 38.1: Whole fish individually frozen.

Whole, gutted or dressed fish in blocks

Figure 38.2: Fillets of fish, frozen in a block, wrapped and packed in a carton.

This is a common form of presentation for small and medium-sized fish intended for further processing. Blocks are rarely more than 10 cm thick or more than 50 kg in weight. Common sizes are 25 kg and 50 kg. Blocks may be unwrapped, or wrapped in plastic film, and are sometimes packed in strapped cartons.

Fillets of fish, frozen in blocks

Fillets of fish are often frozen into geometrically-shaped blocks. Blocks are usually wrapped in plastic film and packed into inner display packs. The display packs are then usually packed in outer cartons.

[1] Gutted fish are whole apart from removal of the viscera.
[2] Dressed fish have heads and guts, and perhaps tails and fins, removed.

Fillets of fish, individually frozen

These are fillets frozen as separate pieces and sometimes coated with batter or breadcrumbs.

Fillets are either placed in packages for retail sale or loosely packed in plastic bags. Small display packs are packed in outer cartons while loosely packed fillets may be packed in bags within outer cartons.

Cephalopods, frozen in blocks or as packaged products

Figure 38.3: Cephalopods (squid) frozen in blocks.

Cephalopods include squid, cuttlefish and octopus. Both processed and unprocessed products are, typically, frozen in blocks weighing 10 or 25 kg. Blocks are occasionally individually packaged, but more usually are overwrapped in plastic, with several blocks packed together in a single outer carton.

Crustacean shellfish, frozen in blocks or as packaged products

These include lobster, crayfish, shrimp and crab. Smaller crustaceans and crustacean meats are often frozen in blocks weighing up to 1 kg. Blocks are packed individually in cartons or overwrapped in plastic film and then packed into outer cartons.

Crustacean shellfish, individually frozen

Large crustacea, such as lobsters and crayfish, are individually frozen, whole or as tails and then wrapped and packed in cartons.

38.2 Freezing and Storage of Fishery Products

The Master of a vessel carrying frozen fishery products does not generally need to be concerned with how the products have been frozen and stored before delivery to the vessel. However, the quality of the cargo discharged from the vessel is affected by freezing, storage and distribution practices before transfer to the vessel, as well as by the manner of loading, stowage and carriage on the vessel.

This section provides some background for Masters and crew about the technologies involved in freezing, storage of frozen fishery products, and the effects of freezing and storage on product quality.

38.2.1 The Freezing Process

When a fish product is cooled in a freezer, its temperature drops rapidly to about minus 1°C (–1°C), when ice begins to form. However, not all the water in the fish turns to ice at this point. As more heat is extracted, more ice forms, but the temperature of the product drops only slowly until about minus 3°C (–3°C). This period, when the product temperature changes very gradually, is known as the thermal arrest period.

The product's temperature then begins to drop rapidly towards the operating temperature of the freezer (see Figure 38.4).

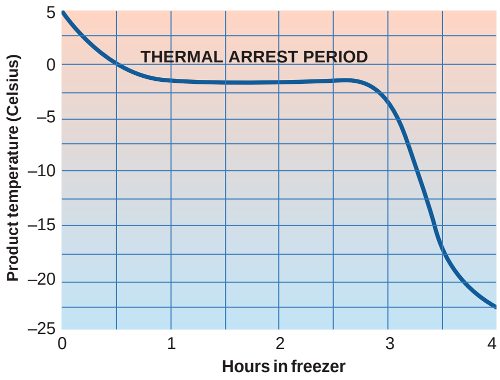

Figure 38.4: Freezing curve of fish initially at 5°C.

To preserve the quality of the product, it is important that the thermal arrest period is as short as possible, preferably less than two hours. This rate of cooling can only be achieved in equipment designed for the purpose; merely placing fish in a cold store will not achieve a sufficiently high freezing rate.

> The refrigerated holds of reefer ships are designed as cold stores to maintain the temperature of already frozen products and they do not have the refrigeration capacity to freeze products at the required rate.

When the product is allowed to thaw, the temperature will follow a curve similar to Figure 38.4, but in the reverse direction.

Brine freezing of individual fish

Brine freezing is used for larger, whole fish like salmon and tuna. The technique is used almost exclusively on board fishing vessels, particularly tuna catchers. The fishing vessel is fitted with one or more insulated tanks containing refrigeration coils. Before fishing starts, these tanks are filled with seawater, which is then cooled to around 0°C. As fish are caught, they are dropped into the tanks. When a tank is full, salt is added to lower the freezing point of the brine and the temperature is lowered so that the fish freeze. The temperature that can be achieved depends on the concentration of the brine, and the minimum, when the brine is saturated, is about minus 21°C (–21°C). In practice, fishing vessels aim for a solution giving a temperature of around minus 12 (–12°C). Once the fish are frozen, the brine is drained from the tank and the fish are held in dry condition with the refrigeration system on.

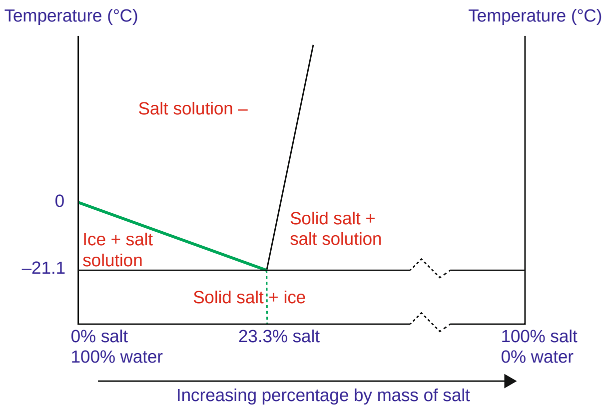

Figure 38.5: Lowering of freezing point of brine.

Freezing of blocks

Small products, including small fish, fish fillets, squid, octopus and shrimps, are often frozen in blocks. The product is laid in trays and frozen, either in a tunnel through which cold air is passed or between pairs of hollow plates through which refrigerant is circulated. The frozen block is knocked out of the tray, protected by some form of overwrapping and usually packed into cartons.

38.2.2 The Quality of Frozen Fishery Products

Complaints about defects in the quality of frozen fishery cargoes usually fall into one or both of two categories:

- Abnormal and offensive odours, flavours or texture, or any other defects that will influence the consumers' perception of quality
- physical damage affecting the processability or merchantability of the product (this can occur during the freezing process, but more usually happens during handling of the frozen product).

Quality defects in both categories can arise during handling, processing and storage of the product before delivery to the vessel, during loading into the holds and while the product is stored on the vessel.

Loss of quality can occur both before and after freezing. However, the nature of the defects differs in the two circumstances and an experienced assessor should be able to distinguish between them.

38.2.3 Loss of Quality Before Freezing

Fish of all kinds are notorious for the speed at which they spoil (even when chilled) and for the unpleasant nature of the spoiled product. Spoilage affects the appearance, odour and flavour of the product. Freezing halts the spoilage process and fixes the quality as it was at the time of freezing. When frozen products are thawed, the quality can be no better than it was at the time of freezing. If defects in the quality of frozen fishery products at the time of delivery are shown to be a consequence of spoilage, no blame can be attached to the carrier of the frozen goods unless the product had thawed out during the voyage.

38.2.4 Loss of Quality During Frozen Storage

Frozen fishery products are not completely stable in the frozen state and will deteriorate over time, resulting in changes in texture, odour and flavour of the product. Changes in texture are similar in character across most fishery products – the product becomes dry, stringy and tough. Changes in odour and flavour depend on the type of fishery product. Lean fish with a low oil content (such as cod) develop the characteristic odours and flavours described as 'musty', 'cardboard' and 'wet dog', while fish with a high oil content (such as tuna, herring and mackerel) develop rancid odours and flavours reminiscent of new leather, linseed oil or old-fashioned oil paints. Changes in odour and flavour in frozen crustacean shellfish and cephalopods are similar to those in lean fish. Oily fish deteriorate faster and produce off-odours more quickly than lean fish during frozen storage.

The main factors influencing the rate at which fishery products deteriorate during frozen storage are temperature of storage and exposure to air. The lower the storage temperature, the slower the product deteriorates. The storage life of fishery products carried at minus 18°C (–18°C) ranges from 3 to 12 months. In general, storage life is halved for each 5°C rise in storage temperature. For example, a product with a storage life of 8 months at minus 18°C (–18°C) will have a storage life of 4 months at minus 13°C (–13°C).

> Since ships' refrigeration systems can maintain products at temperatures below minus 18°C (–18°C), and since voyages are generally less than a month long, there should be no significant loss of quality due to defects in frozen storage during a voyage.

Rate of deterioration is also affected by exposure to air. Block-frozen products are usually protected by close wrapping with plastic film or by coating with a water glaze. To maintain quality, it is important that this cover, film or glaze is not damaged or lost.

Another defect arising during frozen storage is excessive loss of moisture from the product, which leads to general or localised dehydration known as a freezer burn. The dehydration is signified by white patches that appear where the glaze is lost or where there are tears or breaks in the protective wrapping. In unprotected material, dehydration occurs first in thin parts of the product, such as the fins of the whole fish and the tail-ends of fillets, or at the corners of blocks. These dried areas do not rehydrate when the product is thawed and are indicated by blemishes in the thawed product.

38.2.5 Physical Damage to Frozen Products

Physical damage takes a number of forms, but complaints about the quality of reefer cargoes are usually concerned with distortion or compression of the product. This kind of damage, which affects individually frozen fish or blocks of products, occurs when warm fishery products (ie warm relative to the recommended storage temperature) are subjected to pressure, for example in a stack of fish stored in the ship's hold.

Fish typically contain 70 to 80% water, the exact percentage depending on the species. Water in fish tissues starts to freeze at about minus 1°C (–1°C), but at this point only a proportion of the water is converted to ice. Progressively, more water freezes as the temperature falls. At minus 18°C (–18°C), which is the lowest temperature usually specified for the carriage of frozen fish in reefers, around 90% of the water has turned to ice. It is very hard to deform frozen fish at this temperature and below, except under extremely high pressure.

If the product warms at all, some of the ice melts. The fish tissue holds an increasing proportion of liquid water and a decreasing proportion of ice as its temperature rises. As the proportion of ice decreases, the fish tissue, though still partly frozen, becomes softer and can be deformed by moderate pressure. At minus 3°C (–3°C), 'frozen' fishery products are soft enough to deform and to sag under their own weight. If the cargo in the hold of a reefer is stacked to a height of 4 or 5 m, as is often the case, there is sufficient pressure to distort fish to some extent at minus 7°C (–7°C), and to distort and compress fish considerably at minus 5°C (–5°C) or higher.

Individually frozen fish can be severely indented where they lie across each other and also tend to take up the shapes of the surfaces they are pressed against, such as ridged floor plates or edges of structures in the hold. In an extreme case, a stack of fish can be compressed together into a solid mass with almost no spaces between the fish. Blocks of products can be squeezed, flattened and distorted and will extrude into gaps between cartons and be indented by floor plates or pallet boards.

Figure 38.6: Indentations caused when warmed, soft tuna were pressed onto ridged floor plates by the weight of the stack of fish above them.

Frozen products at low temperatures are often brittle and prone to damage by rough handling. For example, tails are easily broken off whole fish and blocks can be shattered or chipped.

Products can also be damaged by contamination. If oil or chemicals are spilled, they may penetrate the wrappings and affect the contents. When cartons and wrappings are torn, the contents are more vulnerable to both contamination and dehydration.

38.3 Pre-shipment Inspection

The need for inspection

Loss of quality in fishery products can be caused by damage both before and after freezing. Carriage of frozen fish by sea is just one stage in a long sequence of processing, handling, distribution and storage operations, and products can be damaged or decline in quality at any stage. Receivers of damaged cargoes of frozen fishery products might allege that loss of quality occurred solely while the material was in the charge of the shipowner.

Pre-shipment inspection is, therefore, essential to determine as far as possible the condition and quality of the product at the time of loading and to note any circumstances that could lead to an exaggerated loss of quality during carriage in the vessel. Such information has an important bearing on any claim that loss of quality or damage occurred during carriage in the vessel. The inspection should take into account the nature of the material, its packaging and its presentation.

Pre-shipment inspection by the ship's officers is generally confined to visual inspection of the cargo and to measurement of physical properties such as temperature. Officers are not expected to carry out detailed evaluations of the quality of the material, which would require examination of material after thawing and perhaps also after cooking.

Nature of the consignment

The deck officer should check that the materials to be loaded are consistent with the B/L. However, information provided on a B/L is usually very brief and a cargo may be described as 'fishery products', which encompasses many different product types. Wherever possible, deck officers should record any additional information, for example, in the case of individually frozen fish, the species or variety, the presentation (whole or dressed) and the name of the fishing vessel.

It is also important to record the details of any labelling on wrapped or cartoned material, particularly production dates or batch codes. The absence of any labelling, particularly of batch or production codes, should also be noted.

Information on the nature of the consignment and all details of labelling should be recorded on the mate's receipt. If labels are detachable, one can be removed and attached to the receipt.

Temperature of the consignment

> It is essential to measure the temperature of frozen fish presented for loading. Since fishery products suffer damage if they are stowed at a high temperature, temperature records provide important evidence of the state of the product at the time of loading.

The terms of carriage normally stipulate the temperature, or at least the maximum temperature, at which the cargo should be carried. Holds of reefer vessels are intended for storage of frozen material loaded at the required temperature of carriage. Refrigeration systems have little spare capacity to lower the temperature of products that are put into the hold at above its operating temperature. Material that is above the operating temperature of the hold will take a long time to cool down and will lose quality as a result.

The terms of contract between the provider of the frozen products and the recipient sometimes specify the maximum temperature at which the products should be stored and delivered to the vessel and a temperature no warmer than minus 10°C (–10°C) would be typical for frozen tuna delivered from a tuna fishing vessel. Even if there is no specific requirement for the cargo's temperature on delivery to the vessel, the Master may refuse to accept a product if he considers the temperature too high and the product at risk of damage during stowage and carriage.

The deck officer should ensure that sufficient measurements are taken to provide an adequate summary of the temperature of the cargo and that the measurements are accurately recorded. Guidelines for temperature measurement are provided in Section 38.5.

During loading, supervising officers should note any softening of the flesh of fish during transfer to the vessel; this can be gauged by pressing the surface of the fish with a thumb nail or the point of a temperature probe. Even when the temperature measured at the core of a fish is low, the flesh on the outside can be soft enough to be damaged by the pressure of a stack within the hold.

Condition of the material

It is not easy to assess the intrinsic quality of frozen products by visual examination but, with experience, one can get some indication of pre-freezing quality from the appearance of the eyes and skin in the case of whole fish, from the colour of the shell in the case of shell-on crustacean shellfish, and from the colour of the skin in the case of cephalopods. These indications of quality will not be visible in packaged products unless some of the cartons are opened. Whenever possible, photographs should be taken of any defects.

Visual indication of spoilage in individually frozen fish

The inspecting officer should examine frozen fish individually for signs of spoilage before freezing.

	Good quality fish	Stale fish
Colours	Bright, demarcated	Degraded and dull
Eyes	Clear or slightly cloudy; flat to the head or even projecting slightly	Yellowish or reddish; sunken or missing
Skin	Clean – no discoloured slime or coating	Abraded and covered with yellowish slime or blood-stained brine; head region of tuna takes on a diffuse pinkish hue
		*Tuna spoiled prior to freezing – note sunken, discoloured eyes, dull colours, pinkish discolouration of head, loss of skin and dirty, bloodstained slime*

Table 38.1: Signs of spoilage in individually frozen fish.

Nature and integrity of packaging and wrapping

Packaging is intended to protect the product from physical damage. The inspecting officer should record any damage to outer wrappings, particularly if the damage has caused exposure of the contents. Sometimes, the packaging includes strapping, particularly where a carton contains individually wrapped, heavy products such as blocks of fillets. The nature and integrity of any strapping should be noted.

Wrapping, which may or may not be supplemented by further packaging in a carton, is intended to prevent contamination and dehydration. Wrapping is only effective in protecting against dehydration if it is sealed or closely applied to the product. The record should include details of the type and condition of any wrapping.

Figure 38.7: Damage to outer carton, although wrapping and contents appear unharmed.

The officer should note any staining of cartons and outer wrappings, including the character and nature of the stain – lubricating oil, fuel oil, water, fish juices, for example. Oils tend to be dark in colour and leave the wrappings soft, even when frozen. Fish-juice stains are yellowish or reddish. The officer should note whether the staining is extensive, covering all or most of the container or wrappings, or localised. When stains are localised, it should be noted whether they are predominantly on the corners or edges of the packages or on the sides.

Blemishes, stains and contamination of the product

When the surface of the product is visible, it should be inspected for blemishes and contamination. Blemishes include surface damage to whole fish, such as abrasions and tears to the skin or splits in the flesh, and surface damage to blocks, such as patches of freezer burn. An attempt should be made to assess the proportion of the consignment affected.

It is important to record any unusual discolouration or staining and, if possible, the nature of the defect, for example blood or bloody brine (particularly on brine-frozen tuna), oil or chemicals. The product should also be examined for contamination by dust, organic matter such as fish offal or vegetable debris, and any other foreign matter.

> In all cases of blemishes or contamination, the inspecting officer should note the extent of the damage and estimate the proportion of the consignment affected.

Signs of thawing or partial thawing

Sometimes, claims are made against shipowners on the basis that a cargo has thawed or partially thawed during the voyage, and has then frozen again to the stipulated carriage temperature. It is, therefore, important to check that a potential cargo does not show signs that it has thawed and refrozen *before* being presented for shipment. Such thawing or near thawing is often indicated by distortion of product shape and release of liquids from the product.

Distortion

Distortion of whole or blocks of fish indicates that the material has thawed or partially thawed since freezing, or was distorted during the freezing process.

Individually frozen whole fish often have slight pressure marks formed during the freezing process. These minor distortions must be allowed for during examination of frozen products. The nature of the marks depends on the freezing process. For example, fish frozen in trays are slightly flattened or have indentations on one side where they have lain on the trays during freezing. Brine-frozen fish tend to float in the brine tanks and are restrained below the level of the brine by a grating. As a result, the fish may have slightly flattened sides where they have been compressed, or shallow cylindrical-shaped depressions where they lay across each other as they froze. Sometimes, the pressure on tuna during brine freezing results in splitting of the skin and flesh, usually on the dorsal surface at the base of the dorsal fin. Any other splitting should be noted by the officer.

> Any distortions other than slight flattening or the presence of minor depressions suggest that the product has warmed up, softened and refrozen in the distorted shape. The officer should note the nature and extent of any distortions.

Blocks of fish should reflect the sharp angles and regular, geometrical shape of the tray or former in which they were frozen. Blocks of fish that have thawed while stored on pallets or in stacks will show signs of slumping, bending or compression and material is often squeezed into the spaces between the blocks. Restraints such as strappings and the framing of pallets and shelf-supports cause indentations in blocks of fish. Again, the inspecting officer should note the nature and extent of distortions.

Release of liquid

Fish release liquid as they thaw. The cargo officers should check for pools of liquid collecting within wrappings, and for signs that liquid has been squeezed from the blocks and has refrozen on the sides of the stack or on shelves and pallets. Staining of cartons is sometimes an indication that the contents have thawed and released liquid.

Figure 38.8: Oil-stained cartons.

Figure 38.9: Carton that has been stained by fish juices when the block partially thawed.

38.4 Transfer, Stowage and Carriage

Temperature control during loading

It is very important for maintaining quality that frozen fishery products are held at low temperatures at all times. Although it is inevitable that the product's temperature will rise during loading into the hold, the loading operations must be conducted so as to keep this rise to a minimum. The product's quality suffers not only due to the immediate rise in temperature as material is stowed in the hold, but also because of the time taken to bring the product back down to the required temperature after stowage.

As far as possible, the cargo should be loaded at, or below, the required temperature of carriage, typically around minus 18°C (–18°C). Officers and crew should attempt to minimise warming of the cargo while it is being loaded and stowed in the holds, preferably so that the temperature of the cargo is not above minus 10°C (–10°C) by the time it is stowed. Although the ship's crew may have little control over loading operations, the Master should cooperate with the ship's agent, and particularly with the stevedoring company, to ensure that good practices are adopted during loading and stowing.

Good practices during loading

- Ensure that delivery to the ship's side is matched to loading onto the vessel to reduce the time that products are waiting on the quay
- products should be delivered in insulated containers or lorries, or at least in covered vehicles
- if the material must be unloaded onto the quay or held on the deck of the reefer, it should be placed on pallets or on an insulating base, packed as tightly as possible and covered with a tarpaulin or similar protection against sun and wind
- the cargo should be protected from exposure to wind, rain and sun until it is about to be transferred to the vessel
- in tropical climates, avoid loading for two or three hours either side of noon and consider loading the vessel at night.

Good practices during stowage

- Ensure that the hold is cooled to below the carriage temperature before loading begins
- during breaks in loading, cover holds or decks with at least the hatch covers, even if the thermal covers are not put in place
- refrigeration to the holds should be turned on during long breaks
- transfer cargo as rapidly as possible from the quay or discharging vessel to the hold
- once loaded, the cargo should be covered with tarpaulins
- where consistent with efficient loading, use only one hatch at a time to avoid through currents of air in the hold.

Maintaining low temperatures during carriage

There is usually an explicit or implicit requirement to hold the cargo below minus 18°C (–18°C) during carriage. The ship's refrigeration system must be capable of delivering air to the holds at a temperature a few degrees below the target temperature to allow for heat leaks through the ship's structures. Cargo spaces in reefers are usually cooled by recirculating air systems, which are only effective if the air can circulate freely through and around the stow.

Most heat leaks into the cargo hold occur through the sides and bulkheads and it is important to ensure that there is free circulation between the cargo and the structures to the hold. Sides and bulkheads should be fitted with vertical dunnage (without horizontal battens which could obstruct airflow) to keep the cargo away from the structures. There should be an even gap of at least 20 cm between the top of the stowed cargo and the lowest part of the deckhead.

Cartons should be stacked with gaps between them, while stows of individually frozen fish will inevitably have spaces unless the fish are deformable and have been compressed.

> The ship's engineer should ensure that refrigeration equipment is well maintained and can achieve the design temperatures. Evaporator coils must be defrosted as required to maintain the cooling capacity. Frequent need for defrosting is a sign of high temperatures in the cargo and should be noted in the engine room log. In addition, the engine room log should record temperatures at critical and meaningful positions in the refrigeration system, such as the outlet and return air streams in air-cooling systems and the outlet and return fluid temperatures in pipe-cooled systems.

It is vital to take and record temperature measurements in the hold. How meaningful these measurements are depends on the location of the temperature sensors. Material in the centre of the stow is the slowest to cool because the source of refrigeration is mainly around the sides of the stow. Refrigerated air percolates gaps between fish or between cartons and the cooling effect depends on the existence of uninterrupted spaces. Sensors attached to the sides or bulkheads of the hold are exposed to cold air circulating through the dunnage against the sides or bulkheads and, therefore, tend to indicate temperatures lower than the bulk of the cargo. Sensors should be attached to posts or other structural members running through the hold, where they are more likely to reflect accurately the temperature of the bulk of the cargo.

Protecting the cargo from contamination

Every effort must be made to protect the cargo from contamination. Good shipboard practices will prevent direct contamination by seawater, bilge water, fuel oil and the like, but it is important to be aware that fishery products are rapidly tainted by odours picked up from the ambient air. This is a vital consideration when using air-cooled refrigeration systems – the air must not become polluted by odoriferous materials such as fuel oil, paints or chemicals used on the ship.

A simple guideline is that, if the air circulating through the hold has an odour, then that odour will be picked up by the fish products.

Unloading

When a cargo is unloaded from the ship, similar precautions should be taken to those recommended during loading to minimise warming. Unloading should be completed as quickly as possible and the cargo should be protected from wind, rain and high temperatures.

38.5 Measuring the Temperature of Frozen Fishery Products

Equipment

The most convenient thermometer for measuring the temperature of frozen food products is a water-resistant, K-type thermometer with a digital display reading to 0.1°C. Typically, these thermometers have a measuring range down to minus 50°C (–50°C) and an accuracy of ±0.5°C in the range required when measuring the temperature of chilled or frozen foods. This accuracy is adequate for the purposes described in this chapter.

There are several types of probe available for plugging into the instrument. The best all-round probe for measuring the temperature of fishery products is a 100 mm long, 3 to 4 mm diameter, stainless steel penetration probe on a 1 m lead. There are also stouter, hammer-in probes for forcing into frozen fish (provided the temperature is not too low), but these have long response times. It is usually preferable to drill holes and use a thinner probe.

Measuring the temperature of frozen fish

It is not usually possible to push a probe into frozen products. Normal practice is to drill a hole, with an ordinary engineer's hand or power drill, of such a diameter that the probe fits tightly. The bottom of the hole should be at the thermal centre of the object, ie at the position that will cool down or warm up most slowly. The thermal centre is usually at the backbone in the thickest part of a fish or at the centreline of a block of fillets. The hole should be around 100 mm deep, ie sufficiently long to take the whole length of the probe. This may mean that the hole must be drilled at an angle to the surface of a fish or along the centreline of a block from one of the smaller side faces.

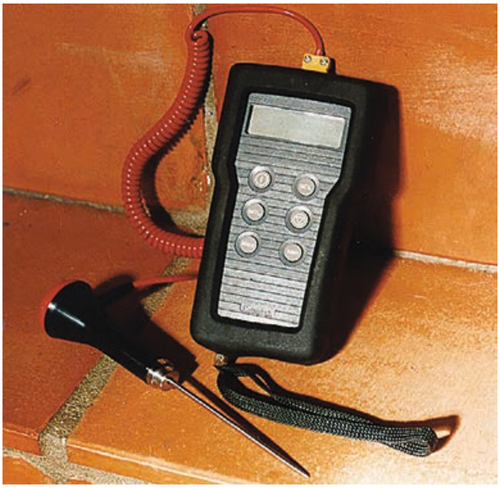

Figure 38.10: Thermometer and probe.

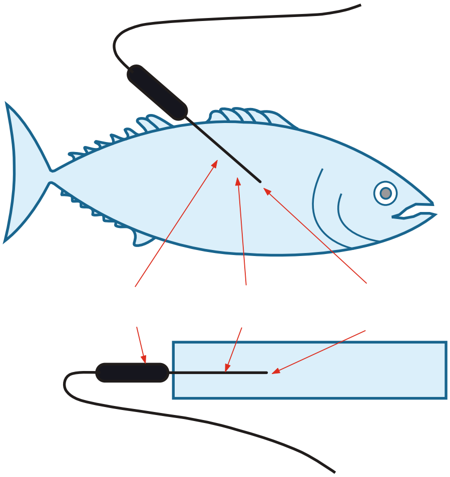

Figure 38.11: Inserting temperature probe into frozen fish or block of fish.

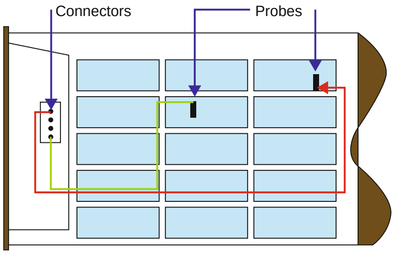

Figure 38.12: Location of thermometer probes.

Once the probe has been inserted, note the lowest temperature reading given in the next 2 to 4 minutes. While the hole is drilled and the temperature measurement taken, the product warms up, so measurements should be taken as quickly as possible, and preferably while the product is still in the hold.

Measuring the temperature of products in cartons

Products in cartons may be delivered in regular stacks or in random loads. In a regular stack of cartons, for example cartons on pallets, temperatures can be measured by inserting the probe between cartons. The warmest areas are the corners of the stack.

Temperature should be measured at diagonally opposed top and bottom corners and in the centre of a face. Insert the whole length of the probe between cartons, or between the flap and body of a carton, on the mid-line. Insert the probe between vertically stacked cartons rather than horizontally adjacent cartons as the weight of the cartons above ensures a good thermal contact with the probe. Record the minimum reading. Pushing the probe between cartons will result in some frictional heating, so 5 to 10 minutes may be required to reach equilibrium. When measuring temperatures of cartons, it is useful to have several probes, cover the stack to avoid heat loss, and allow 5 to 10 minutes before connecting the probes in turn to the thermometer.

Figure 38.13: Measuring temperature within a carton.

When cartons are loosely stowed, it is necessary to measure the temperature within cartons. If the contents are loose, such as individually quick frozen (IQF) fillets, the probe can be forced through the side of the carton into the product.

Thermal contact is poor in such cases and it may take 10 minutes, or more, to reach thermal equilibrium. If the cartons contain blocks, it should be possible to insert the probe between blocks or to drill a hole in a block and insert the probe through the side of the carton. The carton usually has to be split to locate gaps between blocks and the centres of faces of blocks.

Calibration of the thermometer and probes

Instruments are calibrated by their manufacturers, but it is possible to check thermometer/probe combinations at 0°C on the vessel.

Finely crush some ice made from fresh or distilled water and pack it tightly into a vacuum flask or jar. Add cold water to fill the flask and insert the probe to its full length in the ice/water mixture in the centre of the flask. Leave the flask and probe for a while in a cool place, perhaps a refrigerator or chill room, before taking a temperature reading. Since a mixture of ice and fresh water at thermal equilibrium has a temperature of 0°C, any deviation of the probe/thermometer combination from 0°C is the correction for that system.

Figure 38.14: Reefer cargo temperature probe calibration.