

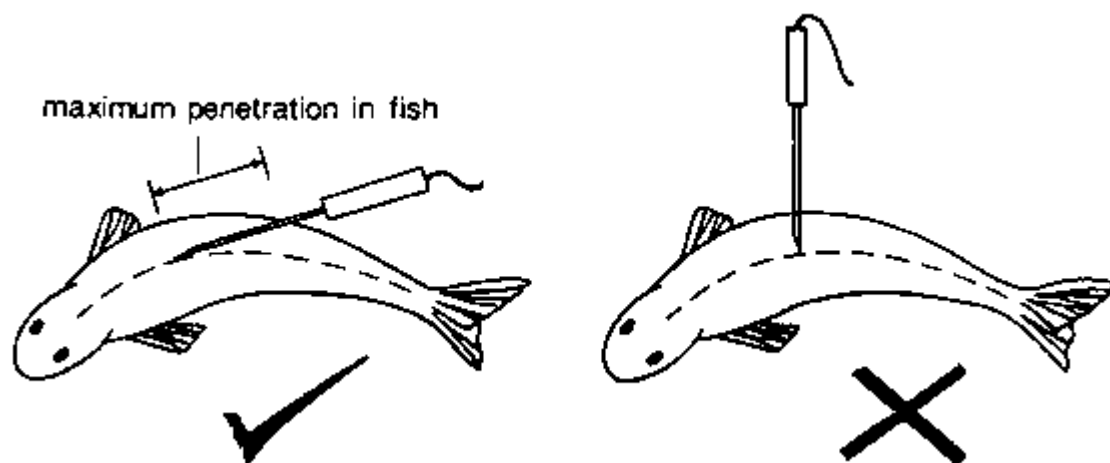


Measurement of temperature inside cold storage / freezer, fish during freezing and thawing

Temperature measurement of wet fish

Fish at 0°C, the temperature of melting ice, will keep in better condition than fish at higher temperatures; therefore in any batch of fish it is important to know the temperature of the warmest fish, since the quality of the batch as a whole may be judged by the condition of these. The warmest fish may be at the centre or on the outside, depending on whether the fish are at the time being cooled or warmed. It is advisable always to take a number of readings at random; for example, in a stack of boxed fish, boxes from the centre, outside, top and bottom of the stack may need to be selected, and temperatures taken of individual fish within each box.

INSERTION OF THERMOMETER IN FISH



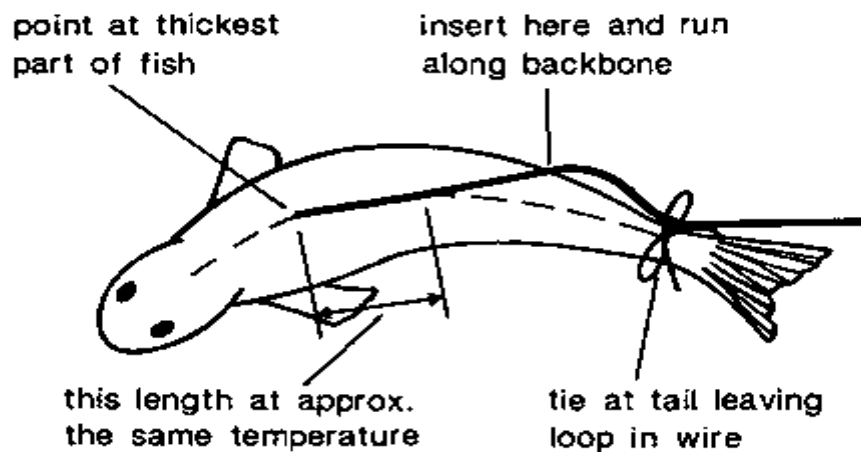
- A very convenient instrument for measuring the temperature of wet fish is a hand-held digital thermometer with a probe type sensor (Appendix, item 4). It is portable and accurate, and has a rapid response which allows readings to be taken quickly. Many instruments are available with thin sharpened probes which can be easily inserted into unfrozen fish.
- The temperature-sensitive element at the end of the probe should be located at the point to be measured, with at least 75 to 100 mm of the probe inserted in the fish, as in the diagram. This reduces any error introduced by conduction of heat along the probe. Special care is required when measuring the temperature of fillets or small products in a chill cabinet. The product should not be removed from the cabinet and should be handled as little as possible to avoid warming it up.
- An instrument used to measure the temperature of wet fish should be accurate to within 0.5°C; the readout is likely to be in divisions of 0.1°C.

Temperature measurement of fish during freezing

- Codes of practice and regulations for quick freezing and cold storage of fish often recommend specific freezing rates and maximum temperatures during storage and distribution. The design of a freezer and the capacity of refrigeration machinery have to be carefully selected to match the desired rate of freezing and final temperature of a particular product. Accurate measurement of freezing time is essential in order to confirm the performance of newly installed plant, and to check periodically the proper operation of existing plant.
- The most suitable sensor for measuring freezing times is the thermocouple (Appendix, item 3). The thickness of the thermocouple wire can be chosen to suit the product being frozen and, since it is comparatively cheap and expendable, the wire can be cut off after freezing, leaving a short, but readily visible, length in the fish which should be recovered when the fish is thawed.
- Since the freezing time of a product is the time taken for the whole of the fish to reach the desired temperature, it is essential that the temperature be measured at the point in the fish that reaches this temperature last. This point, sometimes called the thermal centre, does not necessarily coincide with the centre of a package or the middle of the thickest part of a fish; this will be so only when freezing takes place uniformly from all sides.

- In the example shown here the apparent freezing time to -20°C can vary from less than one hour to $2\frac{1}{2}$ hours, depending on where in the fish the temperature is measured. The shape of a temperature-time curve measured at the thermal centre is characterised by a pause at a steady temperature somewhere between 0 and -2°C , followed by a rapid decrease to near the temperature of the freezer.

CORRECT METHOD OF LOCATING THERMOCOUPLES FOR FREEZING



Temperature measurement of frozen fish

- It is sometimes necessary to check the temperature of frozen fish during handling, transport or cold storage but difficulties arise because of the hardness of the product. Since a probe type thermometer cannot be inserted into white fish that has a temperature lower than -3°C it will be necessary to employ different techniques from those recommended for wet fish.
- If thermocouples have already been used to check the freezing rate of the fish, the ends of the wires remaining in the frozen product can be reconnected to a suitable instrument to measure temperatures at any time during storage or transport. The fish or packages containing thermocouples should be located at points in the store or vehicle where temperatures are most critical, or where they are representative of the bulk of the product.
- Where there is no thermocouple frozen into the product temperature measurement can be particularly difficult, and errors of more than 20°C can result from inadequate

techniques. Different products and circumstances require different solutions and some methods that have proved useful are described.

- The temperature of large blocks of frozen fish can be measured by drilling a hole in the block and inserting a suitable thermometer with a probe type sensor in accordance with the following procedure.
- Remove the fish from the cold store to a place at normal surrounding temperature and drill a neat hole in the side of the block just large enough to take the probe. The hole should preferably be at least 100 mm deep, to avoid errors due to conduction of heat.
- Insert the probe or thermocouple and read the temperature continuously until the lowest reading is reached and the temperature starts to rise again. The lowest temperature observed will be within 0.5°C of the true temperature of storage; any error will be due mostly to warming of the block during the operation which should not take more than two or three minutes. The drilling of the hole has no measurable effect on the temperature of the fish since the heat introduced is quickly dissipated.

Practical points in measuring fish temperature

1. Always measure the most significant temperature; check those fish that are slowest to cool, quickest to warm, or are at the highest temperature.
2. As great a length as possible of the probe should penetrate the fish to avoid errors due to conduction of heat.
3. Measure the temperatures quickly with little or no handling of the fish.
4. Use an instrument that responds quickly to temperature changes and that reads to within 0.5°C of the true temperature.
5. Use an instrument with a small temperature-sensitive element.

Measurement of cold store temperature

- The keeping quality of fish in cold storage depends not only on the temperature of the cold store but also on the steadiness of that temperature. Fluctuations in temperature encourage undesirable changes in the stored product. It is therefore important that a continuous record be kept of the cold store temperature. In large plants a network of sensors with continuous recording would be best for checking the temperature of the cold store air and other

temperatures throughout the plant; in small plants a circular chart recorder with a temperature-sensitive bulb is sufficient (Appendix, item 6).

- The instrument should be capable of detecting small changes in temperature fairly quickly and the bulb should be so placed that it will transmit temperature fluctuations due to opening of the store door. It should not, however, be so near the door or cooling grids that it registers a temperature unrepresentative of the cold store as a whole. Instruments are available for either 7-day or 24-hour operation: if there is no other regular inspection, the daily changing of a 24-hour chart will ensure that the cold store temperature is checked at least once a day. The scale markings on the chart should be in divisions of not more than 1°C and the instrument should record to within 0.5°C of the true temperature.

- **Temperature measurement of air in blast freezers**

Temperature measurement in air blast freezers is like that in cold stores, but because of the greater fluctuations in air temperature the instrument must respond more quickly. The measurements should be made at a point between the cooler and the fish. The instrument should be readable from the loading bay, so that operators can make sure the temperature is right before loading fish. The scale markings should be in intervals of not more than 1°C and the instrument accurate to within 0.5°C.

- **Temperature measurement in smoking kilns**

The temperature of a kiln is controlled or programmed either automatically or manually; in either case it is essential that there is a visual indication of the temperature. It is also essential that the kiln is checked after installation, to determine temperature distribution under fully operative conditions, and periodically thereafter, to maintain a consistent quality of product.

- **Instrument selection**

Thermometers have a number of characteristics which have to be considered when selecting an instrument for a particular use. In order to make the correct choice the user should be familiar with the following terms.

- **Accuracy**

Accuracy is a measure of how close the measured temperature is to the true temperature. This stated accuracy, however, can be achieved only if the instrument is correctly used. Accuracy is expressed either as $\pm x^{\circ}\text{C}$ where x is the maximum deviation above or below the true temperature, or as a percentage of the temperature range of the instrument. Thus, 1% accuracy for an instrument with a temperature range of 100°C is the same as an accuracy of $\pm 1^{\circ}\text{C}$. Although the temperature scale divisions of an instrument may reflect the likely accuracy of the instrument, the true accuracy should be determined by examining the specification of the instrument or by calibration, as described later.

- **Resolution**

The resolution of an instrument is the minimum change in temperature which produces an effective response. Scale division markings should again reflect this resolution since there is little sense in having smaller divisions that suggest a better performance than the instrument can achieve.

- **Range**

The range of temperature that can be measured should match the needs of the user. In general, the narrower the range, the better the accuracy and resolution will be.

- **Response**

The response of an instrument is a measure of how quickly the instrument indicates the temperature to be measured. Generally, the smaller the sensor and the better the contact made by the thermometer the quicker is the response.

- **Operational limits**

Instruments can be used only in locations where the temperature of the environment, the ambient temperature, is within certain limits, usually specified by the manufacturer; for example few hand-held instruments can be used within a cold store. When the temperature is outside these limits, a sensor connected by cable to a remote indicator must be used. The risk of condensation after removing an instrument from a cold environment such as a cold store should be borne in mind, even when the temperature is within the recommended operational limit.