

We measure it.

testo



Pocket Guide Food Safety

Theory – Practical Application – Tips & Tricks

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Testo SE & Co. KGaA, in September 2016

Foreword

Dear Reader

We all consume food daily, and take it for granted that the producers offers us, as consumers, fresh and digestible goods. However, a considerable effort is involved in providing unrestricted enjoyment. Foods go through a complex process before we finally consume them. This requires legal standards, conscientious experts and the appropriate tools for testing quality.

Testo SE & Co. KGaA measuring instruments make a significant contribution to taking foods safely through all processes. It is our objective to provide suitable measuring technology for the different requirements and applications of the professions working in the food sector. That gave us the idea for this “Food Safety Pocket Guide”. It summarizes frequently asked questions when dealing with food. This Pocket Guide is full of interesting information, as well as many tips and tricks from measurement practice, and is intended to be a useful practical support.

Enjoy reading!

A handwritten signature in black ink, which appears to read 'B. Knospe'. The signature is fluid and cursive, written in a professional style.

Prof. Burkart Knospe, CEO

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1. Legal background

1.1 In the interest of world health

Good quality, low germ content and pleasant taste are paramount when dealing with foods. However, raw materials and finished foods which are stored, transported and prepared are exposed to dangers such as damage and spoiling. Reports on food scandals attract public interest and reflect the risks involved in dealing with foods. At the UN (United Nations), the World Health Organization (WHO) has turned its attention to the issues of food safety and health.



“From farm to fork”

This is the ambitious definition of quality assurance in a WHO policy paper of 1992. In 1993, the “HACCP paper” was derived from this, valid for the whole of the European Union – the EU guideline 93/43/EU. This was replaced in 2004 by five regulations, and is today in force in the EU countries and with their trade partners, without the need for the individual countries to make their own legislation.

- EC 178/2002 = General principles and requirements of the food law. Basic document for further directives and regulations.
- EC 852/2004 = Regulation of 29/04/2004 regarding food hygiene.
- EC 853/2004 = Specific regulation regarding foods derived from animals.
- EC 854/2004 = Specific process regulations for official monitoring of products derived from animals.
- EC 882/2004 = Regulation regarding official inspections to verify compliance with laws pertaining to food and animal feed.
- ISO 22000 = Globally valid management system for food safety – requirements for organizations in the food chain.

Fig. 1: The regulations in European food law

1.2 HACCP

HACCP stands for:

Hazard **A**nalysis and **C**ritical **C**ontrol **P**oints

Hazard analysis and critical control points

Why HACCP?

The objective of this concept is to minimize food-related illnesses. Food should be made safer for the consumer. Food-related illnesses are promoted by the following points:

- Globalization (raw products/import/export)
- Convenience products (semi-cooked products)
- Factory farming (salmonella)
- Mass tourism (unhygienic work, time pressure)
- Fast food, too many “producers” (street food)

In order to identify, whether a food may become dangerous, we should ask ourselves the following questions:

- Does the product contain sensitive ingredients?
- Is it intended for sensitive target groups (the aged, the sick, infants etc.)?
- Are preventive programmes or preventive measures provided for in the manufacturing process in order to exclude risks or minimize them?
- Are there potentially toxic basic substances present (fungi, spores, proteins)?

The seven principles of the HACCP concept

The Codex Alimentarius is the basis of the HACCP concept. Self-monitoring is a key point in this. The HACCP concept is to be implemented effectively by means of a 7-point programme:

1. Determination of the relevant hazards (hazard analysis)
2. Identification of the critical control points (CCPs)
3. Definition of limit values (only for Critical Control Points)
4. Definition and implementation of efficient monitoring
5. Specification of corrective measures
6. Production of documents and records (documentation)
7. Definition of regular verification processes (self-monitoring obligation)

The HACCP concept makes a distinction between critical points and critical control points.

Critical points

Critical points (CPs) are those points in the process which, while they do not pose a health risk, can be regarded as critical in the procedure; e.g. quality parameters, compliance with specifications, identification.

Critical control points

Critical control points (CCPs) are points at which there is, in all probability, a relevant health risk to the consumer if this point is not fulfilled (i. e. controlled) e.g. heating steps, sufficient cooling, monitoring of foreign bodies.

1.3 Obligations for food traders

Who does the EU regulation apply to?

The regulation applies across all production, processing and distribution stages for foods and food exports. The food trader plays a key role in this.

Who is a food trader?

A food trader is anyone involved in activities relating to the production, processing or sale of foods. It is irrelevant whether or not these companies are set up to make a profit, or whether they are in the public or private sector.

The central element of the obligations

Documentation

Food traders have an obligation to prove to the relevant authorities that they are conforming to the requirements of the regulation. They must ensure that the documents are up-to-date at all times, and that they are stored for an appropriate length of time.

Training

Food traders must ensure the following:

1. Company employees handling foods are monitored in accordance with the nature of their work and are instructed and/or trained in food hygiene,
2. People responsible for the development and application of this regulation or for the implementation of pertinent guidelines are given appropriate training in all areas of applying the HACCP principle, and
3. All requirements of national laws regarding training programmes for employees in certain food sectors are complied with.

Traceability

The food and animal feed traders must be able to prove when, where and by whom the goods were harvested, produced, processed, stored, transported, consumed or disposed of. This can, under certain circumstances, include traceability back to the original producer, e.g. the farm. This process is known as “downstream”. Traceability from the producer via several processing and trade steps to the shop, and so to the consumer, is referred to as “upstream”.

This information must be made available to the relevant authorities on request.

Compliance with the cold chain for sensitive foods

In the case of foods which cannot be stored at room temperature without potential problems, the cold chain must not be interrupted.

- Any deviations (e.g. during loading and unloading) are only permitted within certain limits (maximum 3 °C) and for a short period of time.
- In means of transport (e.g. containers, trailers, cargo holds of trucks) larger than 2 m², or refrigerated storage areas larger than 10 m³, the temperature must be recorded.
- The thermometers used must be calibrated at regular intervals. This can be done through Testo Industrial Services. More information at: www.testotis.com



Testo measuring instruments for food have obtained the HACCP International certification and are therefore judged to be “food safe”. You can find more information at www.testo.com

Commercial temperature limit values in Germany and the EU

Incoming goods		Storage
≤ +7 °C	Fresh meat (hoofed animals, large game)	≤ +7 °C
≤ +4 °C	Fresh poultry, rabbit/hare, small game	≤ +4 °C
≤ +3 °C	Offal	≤ +3 °C
≤ +2 °C	Minced meat (from EU businesses)	≤ +2 °C
	Minced meat (prepared and sold on site)	≤ +7 °C
≤ +4 °C	Meat preparations (from EU businesses)	≤ +4 °C
	Meat preparations (prepared and sold on site)	≤ +7 °C
≤ +7 °C	Meat products, delicatessen	≤ +7 °C
≤ +2 °C	Fresh fish	≤ +2 °C
≤ +7 °C	Smoked fish	≤ +7 °C
≤ -12 °C	Meat, fish – frozen	≤ -12 °C
≤ -18 °C	Meat, fish – deep-frozen	≤ -18 °C
≤ -18 °C	Deep-frozen products	≤ -18 °C
≤ -18 °C	Ice cream	≤ -18 °C
≤ +10 °C	Dairy recommended	≤ +7 °C
≤ +7 °C	Baked goods with incompletely-baked filling	≤ +7 °C
+5 to +8 °C	Eggs (from the 18th day after laying)	+5 to +8 °C

Hot cuisine

Heat through (core temperature)	> +70 °C
Storage until service	> +65 °C

Cold cuisine

Storage until service $< +7\text{ }^{\circ}\text{C}$

Food service

Hot dishes

Shortly before service $\geq +65\text{ }^{\circ}\text{C}$

Cold dishes

Delicatessen, crudités, cold cuts $\leq +7\text{ }^{\circ}\text{C}$

Unpreserved salads, dressings (milk, eggs), desserts $\leq +7\text{ }^{\circ}\text{C}$

Ice cream $\leq -12\text{ }^{\circ}\text{C}$

Retention samples

Keep for at least 1 week at $\leq -18\text{ }^{\circ}\text{C}$

Disinfection equipment

Water $\geq +82\text{ }^{\circ}\text{C}$

Fig. 2: Limit value table according to EU food law.
These values are monitored by official bodies.

2. Measuring technology in the food industry

Temperature and hygiene play an essential role in the processing and storage of foods. A study carried out by a Belgian restaurant chain showed that incorrect refrigeration was the cause in 56 percent of all cases of spoiled foods.

Hazards when processing food

1. Food is insufficiently refrigerated or heated.
2. Cooked food is stored for too long without refrigeration.
3. Refrigeration systems are overloaded.
Consequence: temperatures are too high.
4. Insufficient attention is paid to personal hygiene of employees.
5. "Clean" and "unclean" processes are not separated strictly enough.
6. Raw and already heated foods are stored together.
7. Liquid from defrosting comes into contact with other food.

2.1 Germ growth

Dependence of germs on temperature for multiplication

The term “germ” refers to microorganisms capable of reproduction. These can only multiply within a specific temperature range.

Germ growth	Temperature
Slows down	< +7 °C
Stopped, germs are “asleep”	-18 °C
Restricted	> +40 °C
Die off	> +65 to +70 °C
Dead (make germ-free)	> +125 °C

Bacteria multiply by dividing. In favourable conditions (depending on moisture and temperature) this occurs every 20 minutes.

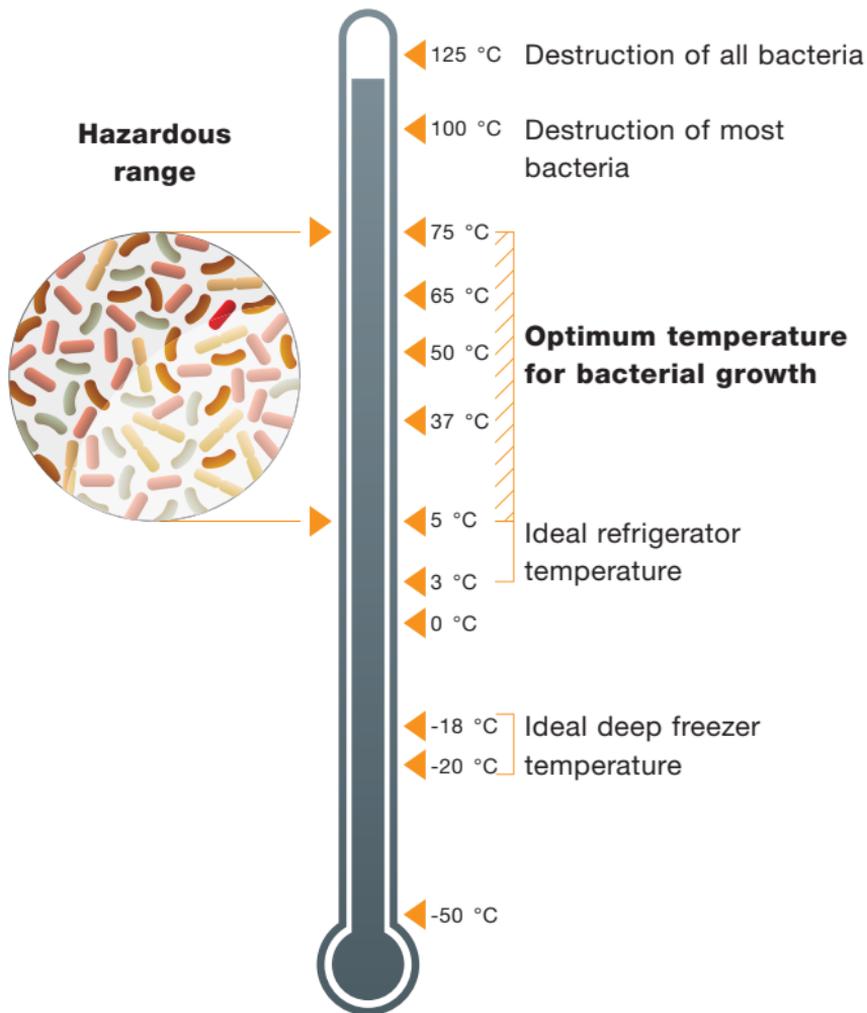


Fig. 3: Temperature-dependent germ growth

Microorganisms – little helpers or a health hazard?

In general, bacteria, fungi and microorganisms are useful helpers (e.g. yeast used in bread making, bacteria which curdle milk or alcoholic fermentation by yeasts). Then again, they can cause serious diseases such as salmonella, E. coli or hyphomycetes. The bacteria do so by using the same “source of nutrition” as human beings: our food.

Germs occur naturally everywhere and are harmless in small quantities. Only when excessive reproduction occurs (depending on the microorganism), does the consumer “notice” the presence of the germs, due to vomiting, diarrhoea or fever. This why attention must always be paid to cleanliness and hygiene, particularly when handling food, because germs often find ideal conditions on food: just 10 cm² of hung pork can contain up to 100 million germs.

Washing or cleaning food and consumer goods significantly reduces the bacterial load. For example, 10 cm² of unwashed lettuce contains up to 1 million germs on average – whereas after washing, there are only up to 100,000 germs. However, germs can hardly ever be completely eliminated: thus, for instance, a clean hand palm will still contain up to 250 germs per cm². In particular, common implements which frequently come into contact with a variety of foods have a high potential for germs. The average germ content of a butcher's scales can be between 750 and 4,000 germs per 10 cm².

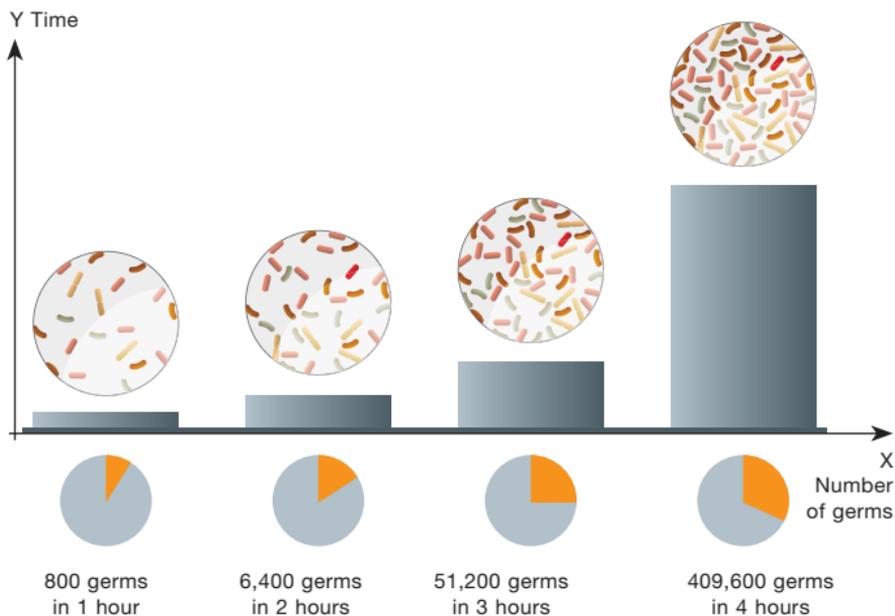


Fig. 4: Reproduction of microorganisms dependent on time

2.2 What is being measured?



Temperature

Temperature is the physical quantity most often measured after time. Different types of thermometer are used. Digital thermometers have established themselves in professional use. These are highly accurate and robust in everyday use.



Relative humidity

Relative humidity is particularly important in connection with the storage of dry goods for prolonged periods of time. Condensation can be caused and foods can absorb moisture, if they are stored in areas for long periods of time. The consequence: mould growth.



a_w value

The a_w value provides information on non-chemically bound water. The measurement is based on the equilibrium moisture. The relative humidity of the ambient air is determined by the free water contained in the solid in an enclosed space with a proportionally lower amount of air than solid. The water activity (a_w value) is virtually the same as the equilibrium moisture in an enclosed space. However, it is not given in 0 to 100% RH, but in 0 to 1 a_w .



pH value

The pH value of foods has a direct effect on the growth of microorganisms. For example, the pH value of meat is a valuable quality feature. In many delicatessen and dairy products, the pH value also plays an important part in terms of acidity and therefore in turn the growth of microorganisms.



Cooking oil quality

The properties and quality of cooking oil are altered mainly by the effects of heat and oxygen. Spent cooking oil, for example, has a negative influence on the taste of the fried goods, and can lead to stomach pains or digestive complaints. However, replacing cooking oil too soon, when it can still be used, leads to unnecessary costs. Therefore, in order to work in an economically efficient way, yet at the same time guarantee the quality and safety of the fried goods, it is absolutely essential to measure the oil quality continuously.



Time

Time plays a large part in the monitoring of foods. This requires the use of measuring instruments which either carry out spot measurements or record data over a defined period of time.

2.2.1 Temperature

Temperature measurement is possible with contact probes or without contact.

Contact measurement of temperature

The contact measurement of temperature can be carried out based on three different technical principles:

1. Thermocouple sensors, e.g. Type T, K, J
2. Platinum resistance sensors, e.g. Pt100
3. Thermistor sensors, e.g. NTC

Comparison of sensors

Thermocouple type T

Measuring range:	-50 to +350 °C
Response time:	very fast
Accuracy:	accurate
Field of application:	all-rounder for food service, incoming goods, kitchen

NTC

Measuring range:	-50 to +150 °C (in some cases up to +250 °C)
Response time:	fast
Accuracy:	very accurate
Field of application:	refrigerated and deep-freeze storage areas, transport monitoring, incoming goods, food service

Pt100

Measuring range:	-200 to +400 °C
Response time:	slower
Accuracy:	extremely accurate
Field of application:	laboratories

There is the right probe for every application
(see appendix 4.3, page 58).

Non-contact temperature measurement

Infrared temperature measuring instruments measure the temperature without contact. However, due to the nature of the system, only the surface temperature is measured, and not the core temperature. The measurement result is extremely dependent on the surface of the goods/packaging being measured. Larger measurement errors can occur in measurements on ice crystals and on polished and reflecting surfaces.



Fig. 5: Infrared measurement of surface temperature on foods

How does infrared measuring technology work?

Every object warmer than the absolute zero point temperature (-273 °C) radiates thermal energy. This thermal energy is in the infrared range which is not visible to the human eye. This thermal energy can be measured and the temperature can be displayed using special optical sensors.

Measuring instrument optics

Infrared measuring instruments are classified by their optics. This number, e.g. 8:1, describes the ideal distance between the measuring instrument and the object of the measurement. This means that at a distance of 8 cm, a measurement spot with a diameter of 1 cm is measured.

The larger this ratio, the greater the distance from the measurement object at which the measurement can be carried out. It is important to keep in mind that the measurement spot should not be larger than the product/packaging.

Stationary measuring instruments for temperature measurement on foods: data loggers

If the intention is not merely to measure data manually, but the requirement is to take measurements over a longer period, so-called measurement data storage devices (data loggers) or data monitoring systems are used.

Data loggers:

- A data logger is an electronic measuring instrument with a memory and clock.
- A data logger records a reading at fixed intervals, to be set by the user (e.g. every 10 minutes, every 30 minutes etc.) and stores it.

Data monitoring system:

- Measurement data are automatically measured and transmitted by data loggers – either to a base station or to an online memory.
- There they are saved, documented and monitored.
- There are a variety of alarm functions available when limit values are violated.

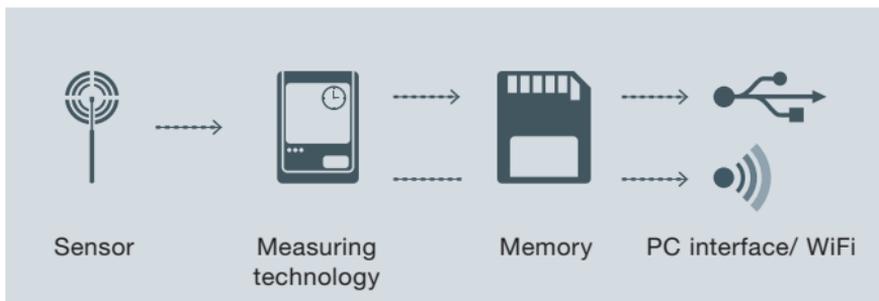


Fig. 6: How a data logger works



Fig. 7: Use of data loggers



Legal requirements for temperature measuring instruments

According to regulation (EC) 37/2005, from the 01/01/2010 temperature measuring instruments for deep-frozen foods in transport, storage and distribution must comply with the following norms:

EN 12830 Requirements for temperature recorders

EN 13485 Requirements for thermometers for measuring the air and product temperature for the transport, storage and distribution of chilled, frozen, deep-frozen/quick-frozen food and ice cream

EN 13486 Test regulations for temperature recorders and thermometers

2.2.2 pH value

The pH value of foods has a direct effect on the growth of microorganisms. The acidity of fruits, salad dressings, jams or similar is a natural barrier to the growth of germs. The lower the pH value, the harder it is for germs to multiply. In bakery products such as sourdough, the pH value is an indicator of the quality and condition of the cooking dough.

However, the pH value is the key thing when it comes to processing meat and sausages. The pH value has a crucial effect on the key product properties such as the water binding capacity, taste, colour, tenderness and shelf life of the meat.

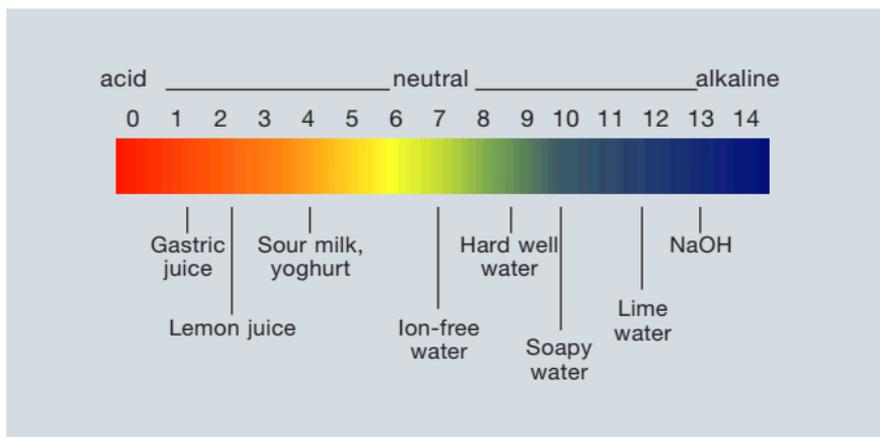


Fig. 8: pH scale with examples provided

2.2.3 Relative humidity

The right storage conditions for foods are of great importance. Microbiological decomposition such as mould depends largely on the moisture present, and is particularly likely to occur due to condensation following temperature fluctuations. Condensate is formed at an air humidity of over 100%. As the air is completely saturated, it cannot carry any more moisture. The gaseous water vapour in the air liquefies. The warmer the air, the more water vapour it can hold without condensation being formed. For this reason, condensation always occurs first on cold surfaces. The so-called “relative humidity” shows how much of the maximum possible quantity of water vapour is present in the air at any given moment. Because this percentage depends on temperature, the temperature has to be indicated at the same time. Probes used to measure relative humidity therefore have to be fitted with an additional temperature probe to record ambient temperature.



Fig. 9: Humidity measurement in supermarket shelves

2.2.4 a_w value

Importance of measuring the a_w value of food

Water activity is a measure of the durability of a product with regard to a number of types of spoiling. In contrast to mere water content, water activity is ideally suited to the evaluation of possible decomposition processes. It is a measure of the availability of water in the reactive medium of a product, and does not simply reflect the mass fraction of the water. In all foods, a portion of the total water content is free and another is bound. The proportion of free water influences the a_w value. The free water is of crucial importance for the growth of microorganisms and their toxin production. However, there are limits below which growth and toxin formation are not possible.

Water activity, water content and food decomposition

Examples of foods

Substance	Water activity / a_w range
Distilled water	1
Tap water	0.99
Raw meat	0.97 to 0.99
Milk	0.97
Juice	0.97
Cooked bacon	< 0.85
Saturated NaCl solution	0.75
Typical indoor air	0.5 to 0.7
Honey	0.5 to 0.7
Dried fruit	0.5 to 0.6

a_w values of microorganism inhibition

Microorganism inhibited	a_w
Salmonella	0.95
Most fungi	0.70
No microbe proliferation	0.60

Source: MÜLLER and WEBER (1996): "Mikrobiologie der Lebensmittel"

[Microbiology of foods]

2.2.5 Cooking oil quality

Due to its composition and the various external influences, cooking oil is constantly exposed to chemical reactions during its life cycle (from filling with fresh oil through to replacement of the aged fat).

A fat molecule always consists of a glycerine (alcohol) and three fatty acids. During the deep fat frying process, the fatty acids are separated from the glycerine residue as a result of different reactions. In addition to free fatty acids, various decomposition products such as aldehyde and ketones are formed.

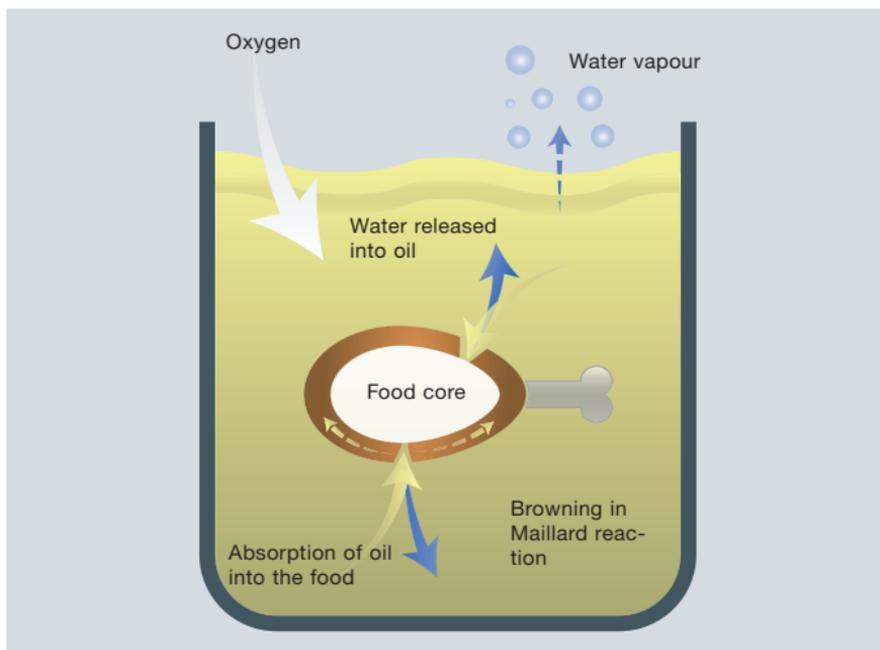


Fig. 10: Reactions between product being deep-fried and cooking oil during the deep frying process

The internationally recognized parameter for cooking oil quality is % TPM “Total Polar Materials”. In many countries, the permitted maximum TPM value is limited by law, e.g.:

Country	TPM value in %
Germany	24
Switzerland	27
Austria	27
Belgium	25
Spain	25
France	25
Turkey	25
Chile	25
South Africa	25

Measurement of the TPM value enables the most efficient use of the cooking fat. The fat can be kept in use until the nationally recommended limit value is exceeded, or it can be continually adjusted to the optimum frying range by partial replacement with fresh oil. This guarantees that the quality of the fried foods can remain constant. In addition to this, regular measurements can also prevent health risks and fines due to a failure to keep within the limit values.

Reliable, fast TPM measurement on site

In addition to expensive and complicated laboratory analysis of TPM, there are also fast testing instruments available which allow reliable measurements on site. The technological principle involved is a capacitive sensor with which the change of polarity

in the cooking oil is measured. This allows conclusions to be drawn about the degree to which the oil has been used, and thus on its quality. The Euro Fed Lipid (European Federation for the Science and Technology of Lipids) recommends the use of such fast test instruments.

Percentage of polar substances

Classification of fat ageing

< 1 to 14% TPM
 14 to 18% TPM
 18 to 22% TPM
 22 to 24% TPM
 > 24% TPM

Fresh cooking fat
 Slightly used
 Used, but still OK
 Heavily used, change fat
 Spent cooking fat



Fig. 11: Measuring the TPM value in cooking oil using the testo 270

3. Tips and tricks

3.1 Practical tips on using food measuring instruments

3.1.1 Temperature measurement

Where is the best place to store the instrument?

The instrument should be stored at ambient temperatures between +4 °C and +30 °C. Storage in an office (department office, workshop, etc.) is recommended. If the instrument is only used for measurement in incoming goods, it can also be stored there. Advantage: the instrument always remains at the ambient temperature and does not need an acclimatization time.



Never store the measuring instrument in the deep-freeze area!

How do measuring instruments react to fluctuating ambient temperatures?

Measuring instruments with thermocouple sensor technology and infrared measuring instruments are dependent on the ambient temperature. If the instrument is only exposed to a cold environment for a short time (1 to 2 minutes), the fluctuation in temperature is negligible. If the instrument is exposed for a longer time, it will need an acclimatization time of 15 to 20 minutes.

How deep should a probe be inserted?

Measurements with penetration probes on non-frozen food

In order for heat to be transferred properly from the food to the probe, the probe should be inserted into the material at least 5 times (or best of all 10 times) deeper than its diameter.

Example: Diameter of the probe tip = 4 mm

Penetration depth = 4 mm x 5 = 20 mm

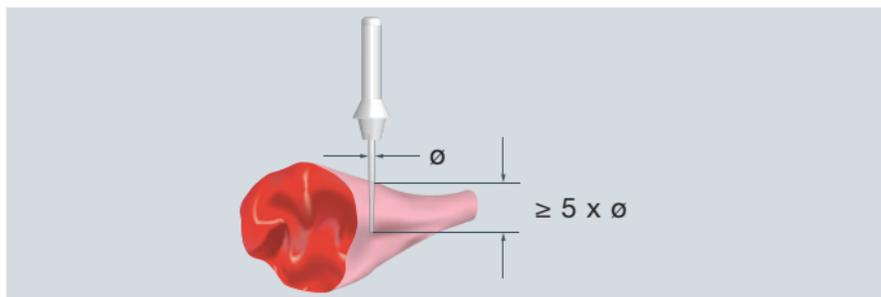


Fig. 12: Penetration depth for measurements with penetration probes

Measurements in frozen food with special probe

For measurements in hard, frozen food, a special frozen food probe is required. It has a self-screwing tip (corkscrew tip). This is screwed in until the thread is no longer visible.



Measure only on sufficiently large pieces of meat (at least 2 kg weight).

Not suitable for pizza, steak, fillets, etc.

Correct use of a surface probe

A wider measuring tip is needed for correct surface measurement.

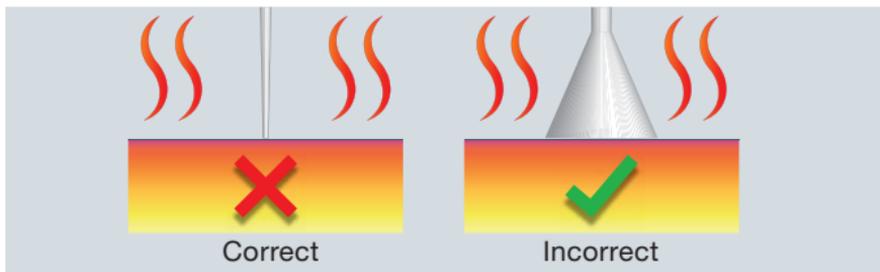


Fig. 13: Using a surface probe

Response time

Each probe requires a certain amount of time to reach the final temperature value for the food which it is measuring.

The technical name for this value is the t_{99} time and it is given in catalogues and brochures. However, it only refers to measurement in water. In foods, this value is higher (approx. 15 seconds to 3 minutes, depending on the design of the probe, the materials and the thickness of the probe shaft).



Fig. 14: Using the testo 108 temperature measuring instrument

Probe accuracy at different temperatures

Display at -18 °C

Probe accuracy specifications

± 0.2 °C	$\pm 0.2\%$ of measured value	± 0.2 °C and $\pm 0.2\%$ of measured value
-17.8 to -18.2 °C	-17.96 to -18.04 °C	-17.76 to -18.24 °C

Display at +25 °C

Probe accuracy specifications

± 0.2 °C	$\pm 0.2\%$ of measured value	± 0.2 °C and $\pm 0.2\%$ of measured value
-24.8 to -25.2 °C	-24.98 to -25.05 °C	-24.75 to -25.25 °C

Display at +100 °C

Probe accuracy specifications

± 0.2 °C	$\pm 0.2\%$ of measured value	± 0.2 °C and $\pm 0.2\%$ of measured value
-99.8 to -100.2 °C	-99.8 to -100.2 °C	-99.6 to -100.4 °C



A measurement is finished when:

1. The required minimum value is reached.
2. The Auto-Hold function fixes the final value in the display.
3. The last digit in the display does not fluctuate by more than \pm one digit.

Non-contact measurement of packaged foods

In non-contact measurement of temperature using infrared measuring instruments, only the surface temperature is measured. With film-sealed foods, only the film temperature is measured. It is therefore recommended that you take the measurements at points which are in direct contact with the food. For cardboard packaging, the box must be opened in order for the measurement to be made directly on the object. Measurement errors can also occur in measurements on ice crystals and on polished and reflecting surfaces.

Legal safeguard for non-contact temperature measurement

Non-contact temperature measurement is ideal for fast temperature control. However, as a legal safeguard, the core temperature must be measured using contact thermometers.

The correct distance for non-contact temperature measurement

The optics describe the ideal distance between the measuring instrument and the measurement object. A short distance is required for the measurement of small objects, and vice versa.

Examples for a measuring instrument with 30:1 optics:

Small measurement object with \varnothing 1.8 cm \rightarrow ideal distance 50 cm

Large measurement object with \varnothing 10 cm \rightarrow ideal distance 2 m

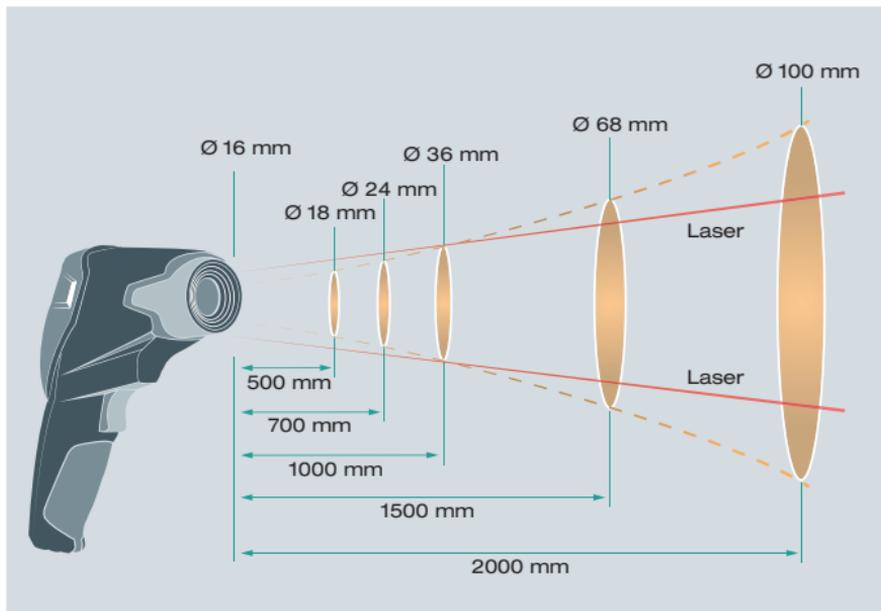


Fig. 15: 30:1 optics of the testo 831 infrared measuring instrument

Tips on the selection of measuring points for data loggers

Suitable measuring points must be selected depending on the measurement task.

Freezers, deep freezers

As well as the product temperature, the air temperature in the freezer is important. It is advisable to measure this in the vicinity of the air recirculation using a suitable probe (air probe). This is where the air is warmest. If the air here is the correct temperature (e.g. $-18\text{ }^{\circ}\text{C}$), the freezer can be assumed to be working properly. Data loggers with several input channels are recommended for monitoring deep freezers over a longer period of time. One probe measures the air temperature at ground level, another at the maximum fill level, while a third measures the air temperature at the air recirculation. For simple monitoring, it is sufficient to place a data logger with an internal temperature sensor in with the frozen goods.

Refrigerated storage areas, storerooms

As well as monitoring the air temperature and product temperature (core temperature of the chilled goods), the use of a measurement data storage device (data logger) is recommended. For refrigerated and deep-freeze storage areas which are larger than 10 m^3 , data recording is even compulsory. According to EN 12830, 15 minutes are considered a suitable measurement interval. The limit values for a data logger are set to the maximum acceptable temperature ($-18\text{ }^{\circ}\text{C}$, $-15\text{ }^{\circ}\text{C}$). If values exceeding the range are detected, the data logger can be read out on the PC. A graph provides a precise picture of when the measurement data strayed over the permissible limits and for how long.



Fig. 16: Temperature monitoring in the refrigerated room with testo 175T1

3.1.2 Measuring the quality of cooking oil using the testo 270 – the right way to measure

Preparation



! Plastic components must not come into contact with the cooking oil.



! Do not touch the hot probe.
Danger of burning.



Remove fried goods before the measurement.

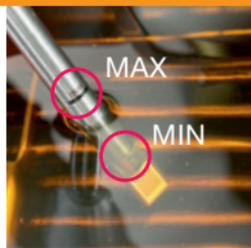


Wait until there are no more bubbles rising (approx. 5 min).

Measurement



Switch the instrument on [O].



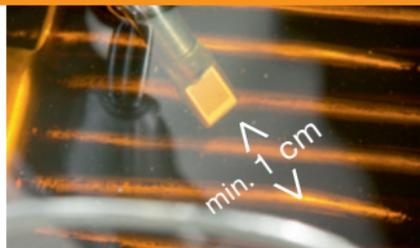
Immerse the sensor in hot oil. Observe min/max marks!



1. Move sensor in oil.

Auto-Hold enabled:

- Auto-Hold in the display indicates the end of the measurement. TPM value and display colour flash until the final measuring value is reached.
- Final value is held.



Maintain a minimum distance of 1 cm from metallic parts.



Measure in hot oil, min. 40 °C, max. 200 °C.



Auto-Hold disabled:

- When the temperature display no longer changes, a stable final value has been reached.
 - To hold measuring values: press **[Hold]** briefly (< 1 s)
2. To return to measuring mode:
press **[Hold]** briefly (< 1 s).



Note the recorded measuring values.

Care & maintenance Cleaning and accuracy test



Clean instrument with mild detergent. Rinse sensor under running water and dry carefully with a soft paper towel.



Your specific starting value:

___ %TPM

For fast and easy instrument testing, we recommend carrying out accuracy tests according to the instruction manual. The reference value must be recalculated if the type of oil or oil supplier changes.



For accurate instrument testing or correction, or in case of implausible measuring values, we recommend calibration or adjustment in Testo reference oil.

Which oils or cooking fats can be measured?

In principle, all oils and fats intended for deep fat frying can be measured. This includes, for example, rapeseed, soya, sesame, palm, olive, cotton seed or groundnut oil. Comparatively higher starting values occur with pure coconut oil (from the core flesh of the coconut) and palm seed oil (not to be confused with palm oil). Coconut oil and palm seed oil are mainly used to make margarine and rarely for deep fat frying. In principle, correct measurement is possible, but this is dependent on the measuring range.



Nowadays, special varieties of rape and sunflower plants (so-called blends or HO oils) with a high content of oleic acid are used instead of pure natural oils. These cooking oils are especially long-lasting and heat-stable.

3.1.3 pH value measurement

Carrying out a measurement

The measuring instrument and the electrodes should first be visually checked to make sure they are in perfect condition before commissioning. If necessary, the measurement system can be calibrated according to the manufacturer's instructions.

After this, the following procedure should be followed:

1. Select the right electrode and instrument for the application.
2. Check the electrode (liquid level, glass breakage, open sealing plug before measuring).
3. Connect electrode to the pH measuring instrument.
4. Rinse electrode with water and dab dry. Friction can generate electrical charges on the glass membrane, leading to a delay in display.
5. Immerse electrode in the measurement solution and stir briefly, then leave to stand. Immerse the electrode so deep that at least the diaphragm is covered by the measurement solution. It is possible that a slightly different pH value is displayed in stirred solutions than in standing solutions. The “unstirred” pH value is usually more accurate. For probes with a protective cage, it must be ensured that there are no air bubbles attached to the glass membrane or the diaphragm.
6. Wait until a stable measuring value has been reached (e.g. with the help of an automatic Hold function) and read off the value.
7. Rinse electrode with tap water and store according to the manufacturer's specifications.

8. The temperature of the measurement solution must be documented with the pH value. This applies to all pH measurements and all pH measuring instruments. For instruments with a fixed electrode, it is not necessary to connect the electrode to the measuring instrument.

Storage



A single-rod measuring cell should always be stored in the solution which is also used in the reference system.

Recognizing ageing symptoms in the pH electrode:

- Increase in response time of the electrode
- Increase in sensitivity to friction on the glass membrane (electrostatic influences)
- Increase in cross sensitivity of the electrode e.g. to sodium ions
- Decrease in steepness¹⁾
- Change in zero-point voltage²⁾

1) The voltage change when a pH value changes by one unit is given as the gradient of the pH electrode. This is also dependent on the condition of the pH electrode (age, load etc.).

2) A single-rod measuring cell is characterized by its gradient and zero-point voltage. While the zero-point voltage is a constant in good electrodes, the gradient of the pH electrode is a function of the temperature. A pH electrode must be calibrated regularly, as its zero-point and its gradient can change as a result of the external measurement conditions and the natural ageing process.

Possible causes of measurement errors:

- Evaporation of reference solution
- Ingress of measurement solution into the electrode
- Defective or blocked diaphragm
- Defective or incorrect reference electrolyte (only for refillable electrodes)
- Incorrect storage

What are buffer solutions?

Buffer solutions are needed for testing and for the calibration of a pH measurement system. They are called buffer solutions because they keep the pH value very stable, i.e. they “buffer” it.

3.1.4 a_w value measurement

How do I obtain reliable measurements?

An accurate a_w measurement is guaranteed when the temperatures of the measuring chamber, sensor and item being measured are identical during or just before the measurement (acclimatization time should be observed where there are temperature differences between the probe and sensor). Measurement at a constant temperature (e.g. +25 °C) is recommended.

Influence of temperature on the a_w value

A generalized statement on the influence of temperature on the a_w value cannot be made. The influence of temperature on the a_w value is dependent on the type of item being measured. There are products whose a_w value increases with increasing temperature (e.g. flour), products whose a_w value decreases with increasing temperature (e.g. lactose) and products which show no temperature dependency.

Duration of the measurement

The duration of the measurement can be different depending on the item being measured. The a_w value measurement is finished when there are no more changes within a defined period.

Fill level

The measuring chamber should be at least half filled.



In principle, the a_w value can be measured when the item being measured is hygroscopic. Substances which absorb or dispense water in humid air with a relative humidity of $< 100\%$ are described as hygroscopic. Sand, for example, cannot absorb water, so it is not hygroscopic. An a_w value measurement for sand is therefore not possible.

3.2 Calibration and official calibration

Calibration/official calibration – who needs what?

Calibration means comparing the measuring instrument with a connected probe to a reference instrument. Calibration provides information on the extent to which the measuring value displayed by a measuring instrument or a measurement system (i.e. the given nominal value of a material measure) corresponds to the respective correct value of the measurement parameter. The “correct” value is represented by a reference norm, which in turn is based on a national norm and thus on the respective SI unit (SI unit = international metric system).

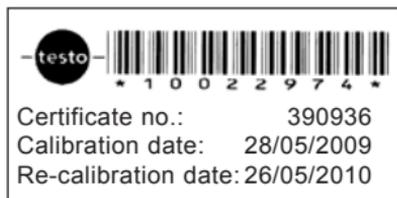


Fig. 17: Calibration seal

The discrepancies are recorded on a calibration certificate. Anyone wishing to carry out measurements in accordance with HACCP/the Food Hygiene Ordinance [LMHV] needs a calibrated instrument.

Calibrations may be performed by all authorized calibration centres.

A core feature of ISO 9000 is the calibration of measuring and test equipment at regular intervals. Since temperature is one of the critical control points in HACCP, the thermometers used must also be calibrated at regular intervals.

Official calibration means “calibration by an authority”. The Board of Weights and Measures calibrates specially approved instruments and probes. The instrument and probe are given a calibration mark that is visible to the user. In this case the calibration certificate is referred to as an official calibration certificate. Food inspectors, veterinarians and other people working on behalf of the government need officially calibrated instruments.

Testo Industrial Services, a subsidiary of Testo SE & Co. KGaA, carries out ISO and DAkkS calibrations for all measuring instruments.



Fig. 18: Using the testo 112 with penetration probe

4. Appendix

4.1 Glossary

A

Absolute humidity

The absolute humidity indicates how many grams of water there are in a cubic metre of air or gas. Unit of measurement: g/m^3 .

Accuracy

Measurement errors or accuracy can be given in three different ways:

- **Absolute specifications:**

In the measuring range, each measuring value that is read off can have a maximum tolerance of ± 0.2 °C, for example.

- **Percentage specifications:**

In the measuring range, each measuring value that is read off can have a tolerance of $\pm 0.3\%$ of measured value, for example.

- **Accuracy specifications with an absolute and a percentage component:**

In the measuring range, each measuring value that is read off can have a maximum basic tolerance of ± 0.2 °C, for example.

In addition, an error of $\pm 0.5\%$ of measured value occurs, which is added to this.

a_w value

The a_w value, also referred to as water activity, is a measure of the freely available water in a material and the shelf-life of foods. It affects the growth of microorganisms, which have different requirements for freely available water. Depending on the availability of free water, microorganisms may multiply or die.

C

Calibration

Procedure in which the measuring values of an instrument (actual values) and the measuring values of a reference instrument (target values) are determined and compared. The result allows conclusions to be drawn about whether the actual values of the instrument are in a permitted limit/tolerance range.

Degrees Celsius [°C]

Temperature unit. Under normal pressure, the zero point of the Celsius scale (0 °C) is the freezing temperature of water. A further fixed point for the Celsius scale is the boiling point of water at +100 °C. $^{\circ}\text{C} = (-32 \text{ }^{\circ}\text{F}) / 1.8$ or $^{\circ}\text{C} = -273.15 \text{ K}$.

D

Data logger

A data logger is a storage unit which records data at certain intervals and saves them in a storage medium. The data logger is often combined with sensors which record physical measurement data over a defined period of time, such as temperature and relative humidity.

E

EU

European Union. Economic union of 28 European states.

F

Fahrenheit [°F]

Temperature unit used mainly in North America.

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32.$$

Example +20 °C in °F: $(+20\text{ }^{\circ}\text{C} \times 1.8) + 32 = 68\text{ }^{\circ}\text{F}$.

G

Germs

Microorganisms capable of life and reproduction.

H

HACCP

HACCP is the abbreviation for “Hazard Analysis and Critical Control Points”.

HACCP International

HACCP International is a globally active organization specializing in processes, risks and controls relating to food safety.

The organization subjects products from a broad range of manufacturers in the non-food sector to stringent, strictly defined quality guidelines. Products that fulfil all criteria earn the status “food safe”. Many Testo products carry this rating, and are therefore deemed safe for use with foods. Find out more at www.testo.com

I

Infrared temperature measurement

All bodies radiate thermal energy. This thermal energy (infrared radiation) can be measured and the surface temperature of the body can be displayed using special optical sensors.

K

Kelvin [K]

Temperature unit.

0 K corresponds to the absolute zero point (-273.15 °C).

The following applies: $273.15 \text{ K} = 0 \text{ °C} = 32 \text{ °F}$.

$\text{K} = \text{°C} + 273.15$.

Example +20 °C in K: $20 \text{ °C} + 273.15 \text{ K} = 293.15 \text{ K}$

M

Maillard reaction

The Maillard reaction (named after the chemist Louis Camille Maillard) is a so-called non-enzymatic browning reaction. It involves the conversion of amino acids and reducing sugars into new compounds under the effects of heat. It should not be confused with caramelization, however both reactions can occur together.

O

Official calibration

Official calibration means “calibration by an authority”.

P

pH value

The pH value is a measure for the acidic or alkaline reaction of an aqueous solution. The pH value is a dimensionless number. It is the negative decadic logarithm (“common logarithm”) of the hydrogen ion activity.

R

Relative humidity (%RH)

Percentage specification of the water vapour saturation level of the air. For example, at 33% RH the air contains only approx. $\frac{1}{3}$ of the maximum volume of water vapour that the air could absorb at the same temperature and the same air pressure.

Resistive sensors (Pt100)

When performing temperature measurement with resistance sensors, the temperature-dependent change in resistance of platinum resistors is used. The measuring resistor is supplied with a constant current, while the voltage drop, which changes with the resistance value as a function of the temperature, is measured. Basic values and tolerances for resistance thermometers are specified in IEC 751.

T

Temperature

State variable for the energy contained in a body.

Thermistors (NTC)

Temperature measurement with thermistors is based on a temperature-dependent change in resistance of the sensor element. Unlike resistance thermometers, thermistors have a negative temperature coefficient (resistance falls as temperature rises). Characteristic curves and tolerances are not standardized.

Thermocouples

Temperature measurement with thermocouples is based on the thermoelectric effect. Thermocouples (thermoelectric couples) consist of two wires of different metals or metal alloys which are spot-welded to each other.

The basic values of the thermoelectric voltages and the permitted tolerances of thermocouples are laid down in the IEC 584 standards. The most widely used thermocouple is NiCr-Ni (the type is referred to as K).

Time

Physical quantity with the formulaic symbol t .

TPM

Stands for “Total Polar Material” and gives the polar fractions in cooking oil, which can be measured using a capacitive procedure.

U

UN

United Nations. International union of 193 states. Internationally recognized organization for ensuring world peace, the observance of public international law and for the protection of human rights.

W

WHO

World Health Organization. Special UN organization for international health, with headquarters in Geneva.

4.2 Testo measuring instruments for food

Temperature			Analysis		
Contact	Infrared	Stationary	pH	TPM	Humidity

Measuring location: Incoming goods

testo 104					
testo 104-IR	testo 104-IR				
testo 105	testo 826			testo 205	
testo 106	testo 831			testo 206	
testo 110	testo 845				
testo 112					
testo 926					

Measuring location: Manufacturing process

testo 103					
testo 104					
testo 104-IR					
testo 105					
testo 106	testo 826	testo 175T		testo 205	testo 270
testo 108/-2				testo 206	
testo 110					
testo 112					
testo 735					
testo 926					

Measuring location: Freezers, deep freezers and glass cabinets

testo 104					
testo 104-IR					
testo 110	testo 826	testo 174T			testo 175 H
testo 735					
testo 926					

Measuring location: Food processing in the kitchen

testo 103	testo 805				
testo 104	testo 826				
testo 104-IR	testo 831				
testo 106	testo 845				
testo 926					

Temperature			Analysis		
Contact	Infrared	Stationary	pH	TPM	Humidity

Measuring location: Deep-frying

					testo 270
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Measuring location: Refrigerated storage areas and storerooms

testo 105 testo 110	testo 805 testo 826 testo 831 testo 845	testo 175T testo Saveris testo Saveris 2			testo 175 H testo Saveris testo Saveris 2
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Measuring location: Transport

	testo 805 testo 806 testo 831 testo 845	testo Saveris			
--	--	------------------	--	--	--

Measuring location: Quality assurance and laboratories

testo 103 testo 110 testo 112 testo 735	testo 805 testo 831	testo 174T testo 175T	testo 206	testo 270	testo 175 H
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You can find more Testo measuring instruments at

www.testo.com

4.3 Probe designs and their application

Immersion/penetration probes



Immersion/penetration probes are designed specifically for measuring temperature in liquids and semi-solid substances (meat, fish, dough, etc.). With sufficient time, they are also suitable for air measurement.

Air probes



Air probes are particularly suitable for measuring air temperatures in refrigerated counters, chest freezers or air conditioning systems (air output temperature), or in the area of ventilation (air input/output), for example.

Surface probes



A wider measuring tip is needed for surface measurement (on packs, packaging, frozen food, hotplates, etc.).

Screw-in probes



To measure the temperature inside frozen food, a probe for measuring core temperature must be inserted into the food. As a rule, a hole must be drilled for this in order to enable insertion of the penetration probe.

We measure it.



Nominal charge EUR 5.00

2981 303X/msp/l/10.2016

You will find the contact details for our subsidiaries and agencies at

www.testo.com