White Paper Tecnosoft
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Response Time Optimisation (T90) in Temperature Monitoring Systems

Abstract

The response time of a temperature sensor represents a critical parameter in regulated industrial processes, particularly in the pharmaceutical and food sectors. This paper systematically analyses the factors that influence the T90 parameter through experimental tests conducted in a controlled environment.
The results demonstrate that variables such as thickness, length, thermal shielding and probe surface area significantly impact the sensor's ability to detect rapid temperature changes, with improvements of up to 70% in optimised configurations.

1. Introduction

In critical thermal processes — such as sterilisation, pasteurisation and thermal validations — the accuracy of the measurement does not depend exclusively on the precision of the sensor but also on its **response dynamics**.
The reference parameter is the **T90**, defined as

> the time required for the sensor to detect 90% of the change between an initial and final condition

A high T90 can lead to:

- delays in the detection of transients
- underestimation of thermal peaks
- errors in the determination of critical process points (cold spots)

The T90 of a sensor or probe can also vary depending on environmental conditions, such as whether it is in air or water and whether the fluid or gas is still or moving and, if moving, how fast it is moving.
Consequently, the design of the measurement system plays a crucial role.

2. Experimental methodology

The analyses presented derive from test campaigns conducted with data loggers equipped with different probe configurations.

Test conditions:

- environment: fan oven
- temperature: 120 °C
- comparison between different geometries and constructions

Variables analysed:

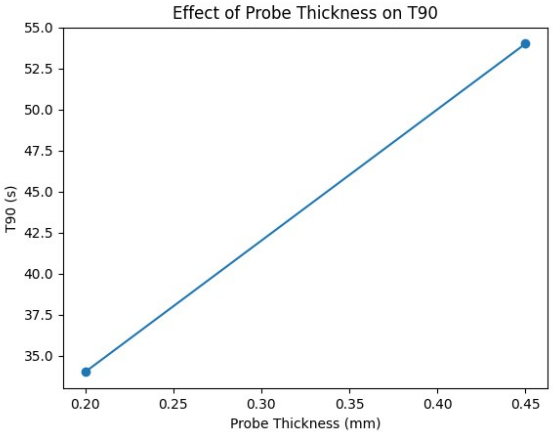
- thickness of the probe wall
- length of the poor
- presence thermal protection
- surface of heat exchange

The experimental approach allowed us to isolate the contribution of each parameter on the response time.

3. Results and discussion

3.1 Influence of thickness

The reduction of the probe wall thickness is confirmed as the most influential factor.
Tests show a reduction in T90 from approximately 54 s to 34 s, going from 0.45 mm to 0.2 mm, a 37% improvement.
This behaviour is due to the lower thermal mass and the greater speed of heat transfer to the sensitive element.

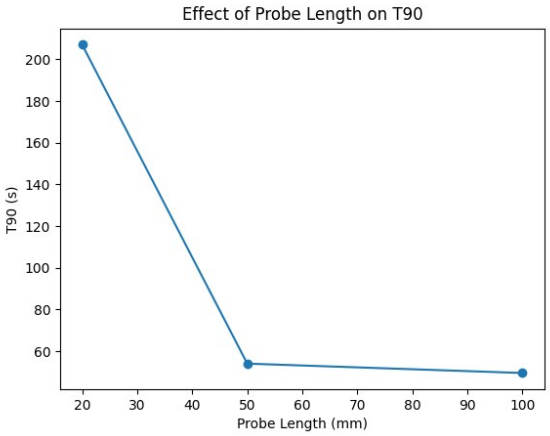


The only disadvantage of this solution is a possible greater fragility of the probe which, having thinner

walls in a process that involves falls, impacts and shock events, could be subject to more frequent damage such as bending or actual breakages.

3.2 Influence of length

The length of the probe has an equally significant impact.
An increase from 20mm to 50mm reduces the T90 from over 200s to around 54s, while further increments up to 100mm produce more modest improvements.
This suggests the existence of an optimal threshold (≈50 mm) beyond which the benefits tend to stabilise.

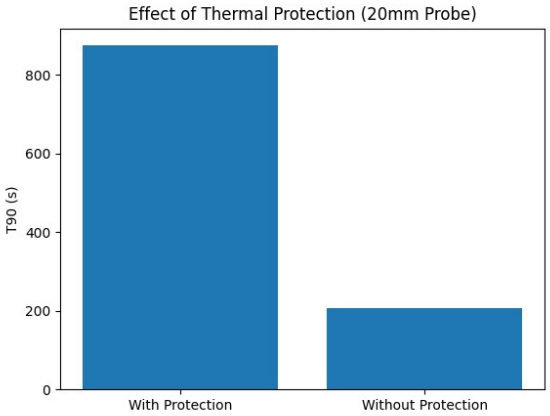


The reason for this difference lies in the fact that the body of the data logger drains heat from the tip, cooling it and thus slowing its response time. By moving the sensing element, which is located at the tip, away from the body, we improve the response time.

3.3 Effect of thermal protection

Thermal shielding introduces resistance to heat transfer.
The effect is particularly marked in short probes:

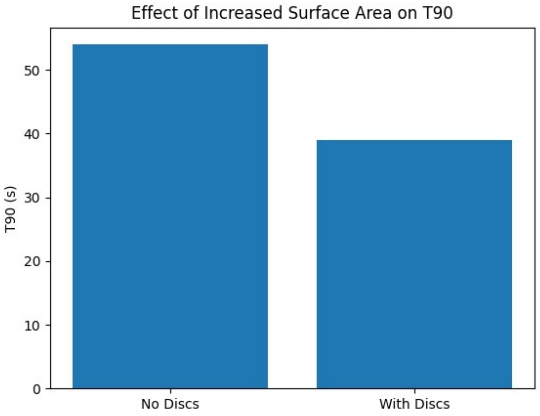
- increase drastic reduction of the T90 in 20mm sensors
- impact marginal for lengths ≥ 50 mm



This behaviour highlights how protection can become a critical factor in applications with small geometries. The reason for this behaviour, amplified, is the same as described in the previous point about probe length.

3.4 Role of the exchange surface

Increasing the contact surface between the probe and the environment improves heat transfer.
The introduction of additional elements (e.g. metal discs along the entire length of the tip) allows for T90 reductions of up to approximately 28%.
This opens the way to advanced design solutions oriented towards geometry optimisation.



3.5 Secondary parameters

The analysis highlights that:

- the shape of the tip does not significantly affect
- the outer diameter has negligible impact

These elements can therefore be optimised for mechanical or application needs without compromising thermal dynamics.

4. Implications for design

The experimental results allow us to define some design guidelines:

- to privilege thin walls to reduce thermal mass
- to adopt lengths ≥ 50 mm to ensure adequate response times
- to minimise or optimise thermal protection in compact sensors
- increase the exchange surface when possible

Further developments include:

- use of highly conductive materials (e.g. copper) where it does not go into conflict with other needs, such as the use of food materials grade
- solutions hybrids with coatings compatible with food environments
- configurations “naked” for specific applications to be used only in dry environments

5. Application impact

Pharmaceutical sector

- greater reliability in thermal validations
- best control of sterilizing processes
- support to regulatory compliance (GMP, FDA)

Food sector

- identification more accurate than cold spots
- reduction of microbiological risk
- optimisation of process cycles

Industrial monitoring

- greater fidelity in recording transients
- best data quality for analysis and audit

6. Conclusions

The T90 response time represents a key parameter in the quality of thermal measurement.
Experimental evidence shows that:

- thickness and probe length are the predominant factors
- the thermal protection must be evaluated according to the geometry
- optimisation of the surface offers further room for improvement

An engineered sensor design enables significant T90 reductions, improving overall monitoring system reliability and process safety.
A higher T90 and therefore a slower response time, is not necessarily worse than a lower T90 and therefore a faster response time. The choice depends largely on the process and the analysis needs. In processes where thermal variations are minimal and sporadic, a fast T90 is not necessary, just as it is not useful in monitoring applications where sudden peaks must be avoided because they are insignificant with respect to maintaining the quality of the monitored product, such as in environmental monitoring, refrigerators and cold storage rooms. In fact, the monitored product in most cases has a significantly slower response time than that of the probe and sporadic and extremely short-term fluctuations do not affect its potential degradation. A probe that is too fast would generate false alarms.

7. Positioning of Tecnosoft solutions

In light of the experimental results, the choice of the measurement system cannot ignore the sensor configuration and the data logger architecture.
The solutions **MicroW** and **BlueWave** represent two complementary approaches, designed to optimise the trade-off between **response time, application flexibility and data management**.

7.1 MicroW: Optimising the T90 for Critical Applications

The MicroW family is designed for applications where the **response time is a determining parameter**, such as:

- thermal validations (autoclaves, ovens, tunnels)
- studies thermal penetration (food)
- identification cold spots

Key points compared to the T90:

- availability Of wall probe thin (0.2 mm) → significant reduction in T90
- possibility to choose lengths ≥ 50 mm → dynamics optimization

- configurations with custom tips for application adaptation

Technical positioning:
MicroW is the ideal solution when the objective is **maximise response speed and accuracy in thermal transients**.

7.2 BlueWave: Real-time monitoring and operational flexibility

The BlueWave series introduces a new approach wireless and real-time, maintaining thermal performance consistent with industrial needs.

Typical application

- monitoring process continua
- studies dynamic with immediate visualisation
- environments where connectivity is a critical factor

Key points compared to the T90:

- integration with **thin probes and bendable**
- possibility to observe in real time the effect of T90 on the process
- greater decision-making responsiveness during testing

Technical positioning:
BlueWave is the ideal choice when, in addition to the T90, it is essential **see and interpret the thermal phenomenon in real time**.

7.3 Choice of solution based on the application

Application needs	Suggested solution
Maximum precision on transients	MicroW
Validations according to regulations (GMP/FDA)	MicroW, BlueWave
Real Time Continuous Monitoring	BlueWave
Dynamic Tests with immediate feedback	BlueWave
R&D Optimisation on sensors	MicroW + BlueWave

7.4 Integration between hardware and probe design

Experimental results demonstrate that performance does not only depend on the type of device but also on the **probe**.

Tecnosoft allows:

- selection of **optimised geometries (thickness/length)**
- development of **custom configurations**
- integration with alternative materials (e.g. copper) for advanced applications

This approach allows the measurement system to be transformed from a simple acquisition tool to **engineering lever to improve the process**.

8. Adopting a correctly configured solution allows:

Adopting a correctly configured solution allows:

- reduction of measurement errors in transients
- greater reliability in validations
- optimisation of thermal cycles (time/energy)
- reduction of the risk of non-compliance

Contacts

For further information or to evaluate the most suitable configuration for your application, you can contact the technical team by writing to sales@tecnosoft.eu.

Tecnosoft srl
Via Luigi Galvani, 4, Peschiera Borromeo, 20268 (MI) – ITALY
T: +390226922888
tecnosoft.eu