THERMOMETRICS
A COMMITMENT TO EXCELLENCE

Application Spotlight

Thermistor Stability Benchmarking (1)

Overview

Temperature sensing applications, and the accuracy of the output, are directly related to the performance of the temperature sensing element (i.e., the thermistor).

NTC thermistor electrical performance is determined by four factors:

1. Reference resistance
2. Beta value (NTC curve shape)
3. Temperature measurement accuracy
   ± % tolerance & ±°C accuracy of the product specification
4. Long term resistance stability
   Maintaining the supplied tolerance and accuracy during operation in the field

Healthcare Applications

* Typical tolerance ±0.2°C between 25°C and 50°C

* Clinical accuracy/stability is essential for disposable and fixed applications

- Avoiding misdiagnosis is critical. Incorrect temperature readings from an oral thermometer, neonatal skin surface sensor or thermo-dilution catheter accuracy hinder the doctor or care-giver's ability to properly diagnose and treat the patient
- Accurate temperature measurement is a key factor to enhance patients' comfort and safety during treatment involving water, gas, or lasers at elevated temperatures, and assisting in tasks such as personal hygiene or cosmetic surgery
- Thermistors are often used as the temperature monitoring and control function of medical equipment. Incorrect feedback on temperature from the thermistor could lead to item/equipment reuse without correct cleaning processes Response time

AAS Advantage

- Amphenol component accuracy supplied at ±0.2°C at 50°C, typical medical tolerance
- Amphenol resin-coated devices have excellent stability performance at elevated temperature 100°C (operational temperature 45°C)

Temperature Stability @ 100°C for 1000 hours			
Supplier	Δ R25%	Δ °C	Performance Ranking
Amphenol	**0.08**	**0.018**	**1**
A	0.16	0.069	2
B	0.22	0.050	3
E	0.24	0.055	4
V	0.30	0.068	5
K	0.62	0.141	6

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Product Spotlight

Thermistor Stability Benchmarking (2)

Exhaust Gas Recirculation (EGR) Applications

- Typical Tolerance: ±5°C at 300°C
- Typical Tolerance: ±1°C at 150°C
- Accuracy/stability is essential for efficient combustion control.

- Emission Concerns – Sensor interprets air temperature incorrectly, creating a difference between the actual control temperature and the engine design temperature emission mapping value.
- Engine Performance – Sensor interprets air temperature incorrectly, causing the engine to operate to a condition not optimized for peak performance and efficiency.
- Engine Life – Sensor interprets air temperature incorrectly, resulting in excessive engine temperature, which would decrease engine components and fluid life.

Resin-Coated Thermistor Elevated Temperature Stability

Supplier	300°C @ 1000 hours		250°C @ 1000 hours		Performance Ranking
	Δ R25 %	Δ °C	Δ R25 %	Δ °C	
Amphenol	0.27	0.062	0.35	0.080	1
E	0.40	0.091	-0.46	0.105	2
S	-0.64	0.146	-0.64	0.146	3
K	0.69	0.157	1.26	0.287	4
V	-2.58	0.588	-2.5	0.57	5
K	64.8	14.77	72.7	16.57	6

AAS Advantage

- Amphenol supplies both glass-encapsulated and resin-coated thermistors for EGR systems, based on temperature applications. i.e. ±5°C at 250°C/300°C and ±1°C at 150°C, typical high temperature EGR tolerances.
- Amphenol thermistors have excellent stability. The glass-encapsulated components show 0.062°C measurement accuracy at 300°C and 0.080°C at 250°C after 1000 hours. The resin-coated parts show 0.043°C accuracy at 170°C after 1000 hours.

Resin-Coated Thermistor Elevated Temperature Stability

Supplier	170°C @ 1000 hours		Performance Ranking
	Δ R25 %	Δ °C	
Amphenol	-0.19	0.043	1
V	-0.21	0.048	2
A	1.57	0.358	3
E	1.85	0.422	4
B	2.65	0.604	5
S	4.6	1.049	6
K	5.54	1.263	7

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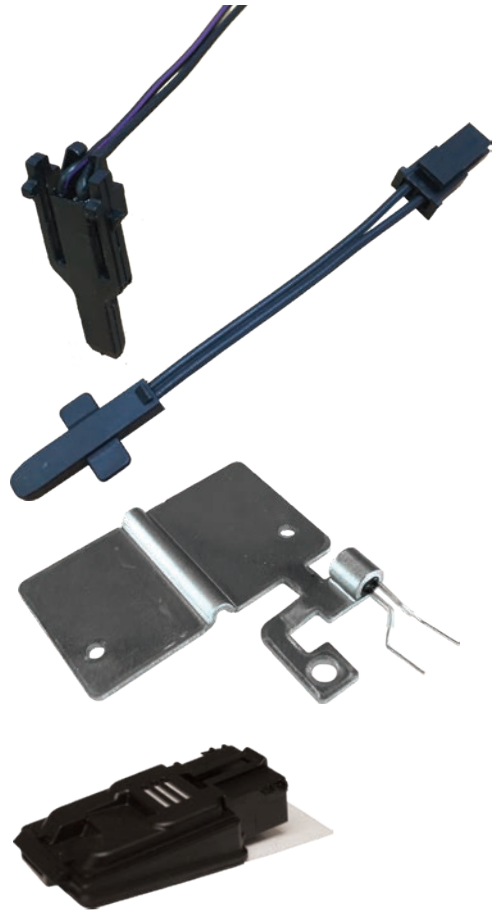
Application Spotlight

Thermistor Stability Benchmarking (3)



Battery Temperature Sensing - EV/HEV/PHEV

Typical Tolerance: ±0.4°C at 45°C

Accuracy/stability is essential for battery protection.

- Unstable thermistors may not detect over-temperature when the battery pack is charging. The Battery Management System (BMS) may not deliver sufficient charge, or the battery may suffer permanent damage.
- Unstable thermistors may diminish efficiency through partial charging. Partial battery power causes reduced vehicle performance, lifetime and mileage.

Defog Temperature Sensor

Typical Tolerance: ± 0.23°C at 25°C

Accuracy/stability is essential to avoid cabin moisture condensation.

- Thermistor in defog sensor detects windshield temperature (Tg). Inaccurate Tg detection will cause the HVAC system to incorrectly calculate the dew point temperature of the windshield.
- A fogged windshield reduces visibility for the driver, especially under limited light and poor weather conditions.

AAS Advantage

- Amphenol component accuracy supplied at typical EV battery tolerance of ±0.4°C at 45°C, and typical defog temperature sensors of ±0.23°C at 25°C.
- Amphenol resin-coated devices have excellent stability performance at elevated temperature 100°C, showing higher NTC stability at 45°C operational temperature and 25°C cabin temperature.

Temperature Stability of Resin-Coated Thermistors

Supplier	100°C @ 1000 hours		Performance Ranking
	Δ R25 %	Δ °C	
Amphenol	**0.08**	**0.018**	**1**
A	0.16	0.036	2
B	0.22	0.050	3
C	0.24	0.055	4
D	0.30	0.068	5
E	0.62	0.141	6

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Application Spotlight

Thermistor Stability Benchmarking (4)

Automotive Oil, Coolant, and Water Temperature Sensors

** Typical Tolerance: ±1.1°C at 90°C*

** Accuracy/stability is required for engine efficiency.*

What are the application implications of reduced stability thermistors?

- Reduced engine performance, component reliability, lifetime of gasket and seals. If a thermistor drifts high resistance, the engine potentially operates at a high temperature.
- Losing operating efficiency. If a thermistor drifts low resistance, the engine potentially operates at a lower than optimal temperature.
- Exceeds emissions regulations.
- Cooling fans not operating when the engine requires additional cooling, leading to engine overheat.
- Increased fuel consumption. Incorrect fuel mix ratio demand from engine management system due to incorrect engine management temperature inputs.

Thermal Shock of Resin-Coated Thermistors (-40°C/15mins - +150°C/15mins, 1000 cycles)

Supplier	Δ R25 %	Δ °C	Visual Defect	Performance Ranking
Amphenol	-0.06	0.014	0	1
A	0.82	0.187	19/20 cracked; 1/20 resin spalling	2
B	0.84	0.193	20/20 cracked	3
C	1.44	0.328	20/20 cracked	4
D	2.79	0.636	8/20 crack; 18/20 resin spalling	5
E	4.55	1.037	20/20 resin spalling	6
F	7.57	1.726	20/20 resin spalling	7

AAS Advantage

- Amphenol NTC devices have robust performance under thermal cycles, showing measurement accuracy change 0.014°C at 25°C, without damage after 1000 cycles in accelerated tests.
- Amphenol resin-coated devices have excellent stability performance at elevated temperature 150°C, showing 0.04% resistance shift, equivalent measurement accuracy change 0.009°C at 25°C, and 0.013°C at 90°C after 1000 hours.

Temperature Stability of Resin-Coated Thermistors

Temperature Stability @ 100°C for 1000 Hours			
Supplier	Δ R25%	Δ °C	Performance Ranking
Amphenol	**0.04**	**0.009**	**1**
A	-0.15	0.034	2
B	2.86	0.652	3
C	2.89	0.659	4
D	2.91	0.663	5
E	2.93	0.668	6
F	8.72	1.988	7

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THERMOMETRICS
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Application Spotlight

Thermistor Stability Benchmarking (5)

Thermocon / HVAC / DATS

** Typical Tolerance: ± 0.2°C at 0°C*

** Accuracy/stability is essential to maintain cabin environment.*

- The Thermocon is used to control the temperature of the evaporator in car air conditioning systems. Misreading the evaporator temperature results in icing on the heat exchanger, restricting cooling capacity and diminishing the performance of the air conditioning system.
- Discharge Air Temperature Sensors are used to provide feedback control to cooling and heating equipment. If the thermistor used is not stable or accurate, the occupants may feel uncomfortable due the occupant area being cooler or warmer than the desired setting.

Boiler and Pipe Applications

** Typical Tolerance: ±0.85°C at 63°C*

** Accuracy/stability is required for mechanical efficiency.*

- The Temperature Sensors are used to either create, control or maintain a pilot flame in the boiler, or to build in the control system to monitor water level in the boiler. Thermistor accuracy and/or stability issues can lead to reduced efficiency and performance of the boiler.
- Pipe Clip Sensors are typically used in processing applications to measure the inlet and outlet temperatures. Inaccurate or unstable thermistors could signal incorrect information about the heat exchange rates, the process efficiency and EHS or legislation requirements.

AAS Advantage

- Amphenol Component Accuracy: Typical ± 0.2°C at 0°C and ±0.85°C at 63°C.
- Amphenol resin-coated devices have excellent stability performance, showing 0.08% resistance shift, equivalent to 0.02°C measurement accuracy change after 1000 hours at elevated temperature 100°C, the higher NTC stability at the operational temperature at the applications.

Temperature Stability of Resin-Coated Thermistors

@ 100°C for 1000 Hours			
Supplier	Δ R25%	Δ °C	Performance Ranking
Amphenol	**0.08**	**0.018**	**1**
A	0.16	0.036	2
B	0.22	0.050	3
C	0.24	0.055	4
D	0.30	0.068	5
E	0.62	0.141	6

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