

HOW TO CHOOSE THE RIGHT TEMPERATURE SENSOR FOR YOUR APPLICATION

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OUR HERAEUS NEXENSOS EXPERTS

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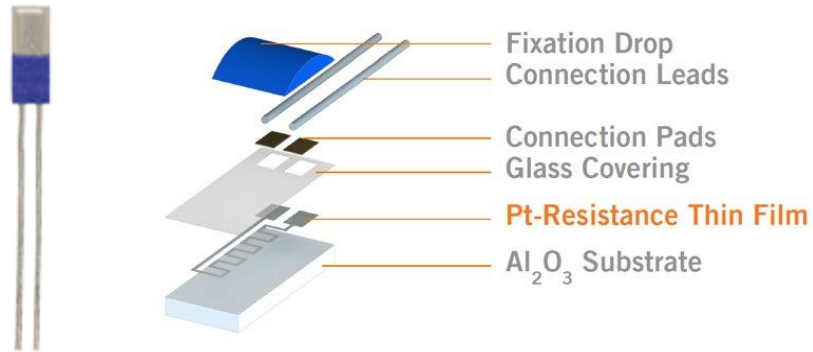
AGENDA.

THEORETICAL OVERVIEW

APPLICATION DEEP DIVE

- BODY TEMPERATURE MONITORING
- E-MOTOR
- HEAT METERING
- EXHAUST GAS TREATMENT
- INDUSTRIAL CLOTHING IRON

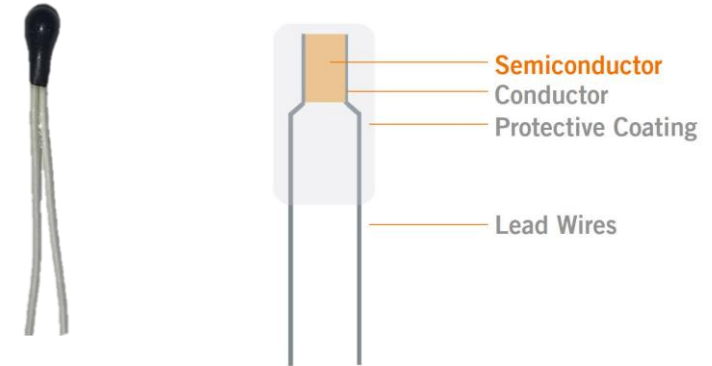
THEORETICAL OVERVIEW



PTC – Positive Temperature Coefficient

Pt RTD – Platinum Resistance Temperature Detector

- Our sensors are based on thin film technology
- Typical configurations:
Elements with lead wires, SMD types, SOT223, TO92



NTC thermistor – Negative Temperature Coefficient

- Bulk resistor based on semiconductor ceramics
- Typical configurations:
Elements with lead wires, SMD types, diode package



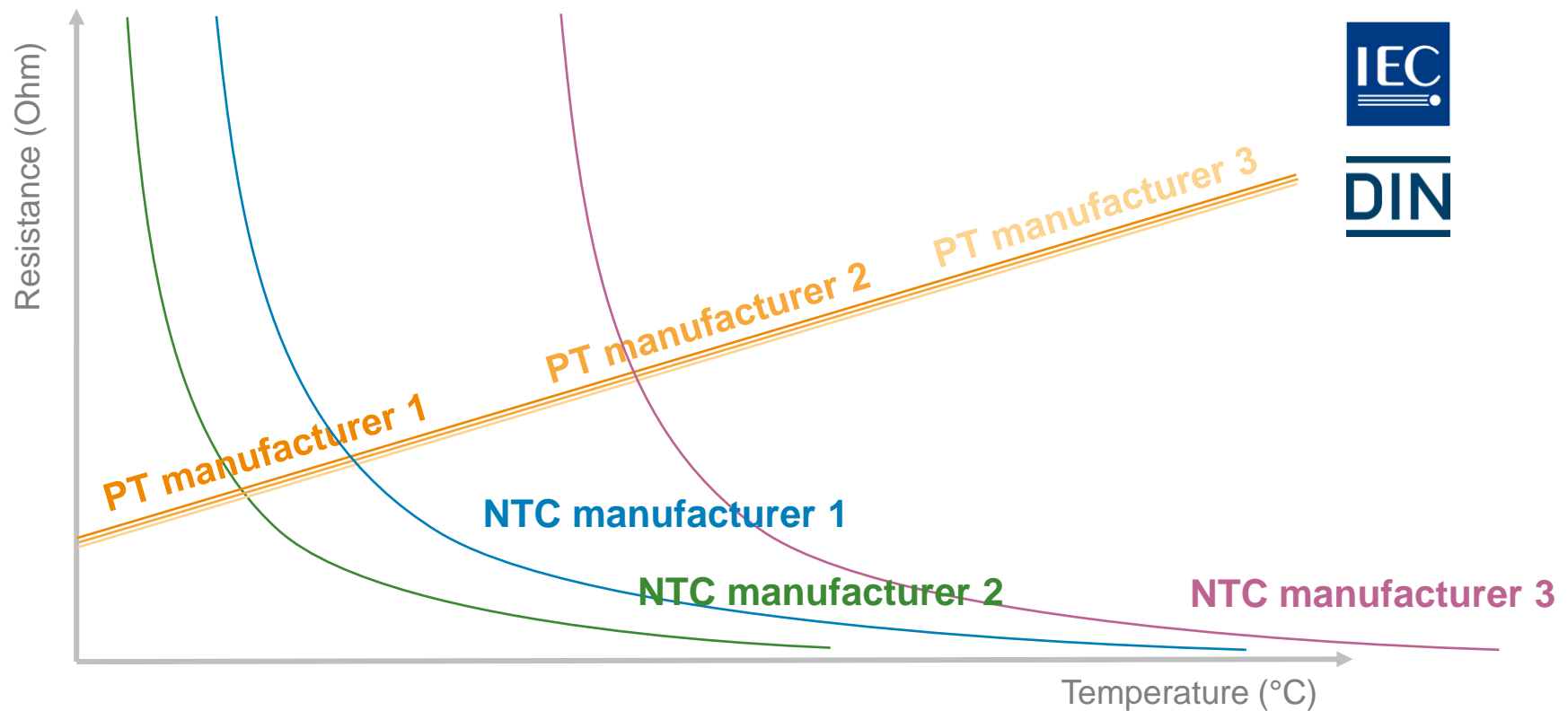
THEORETICAL OVERVIEW

PT

- Positive Temperature Coefficient
- Typical resistance values: 100, 500, 1000 ohm (@ 0 °C)
- Linear characteristics (TCR 3850 ppm/K)
- Typical operating temp. range: -196 °C to +1000 °C

NTC

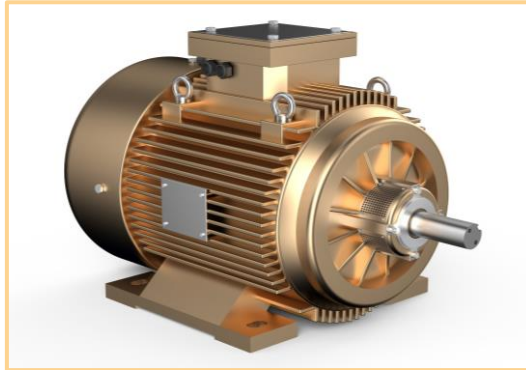
- Negative Temperature Coefficient
- Typical resistance values: 2252 ohms and higher (@ +25 °C)
- Non-linear characteristics
- Typical operating temp. range: -100 °C to +300 °C



TEMPERATURE SENSING APPLICATIONS



BODY TEMPERATURE MONITORING



E-MOTOR



HEAT-METERING



INDUSTRIAL CLOTHING IRON



EXHAUST GAS TREATMENT

NTC THERMISTOR APPLICATION: PATIENT MONITORING

APPLICATION CONDITIONS



Narrow Temp. Range

From +32 °C to +42 °C.



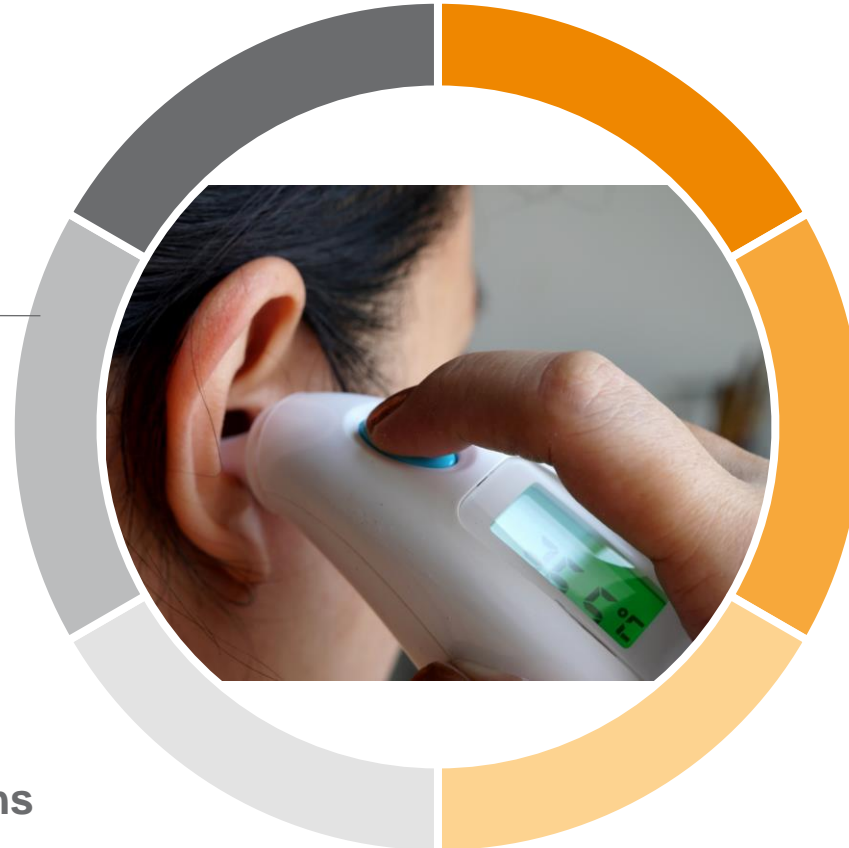
Small Sensor Footprint

To minimize patient discomfort.



Relatively Long Lead Lengths

1-2 meters of small diameter wire.



REQUIREMENTS FOR TEMPERATURE MEASUREMENT

Precise Temp. Measurement

Small changes in temperature & trending can have large impact on patient.



Interchangeability

Ability to change sensor without recalibration is essential.



Fast Response Time

Some conditions cause rapid increase in body temp. that must be addressed immediately.



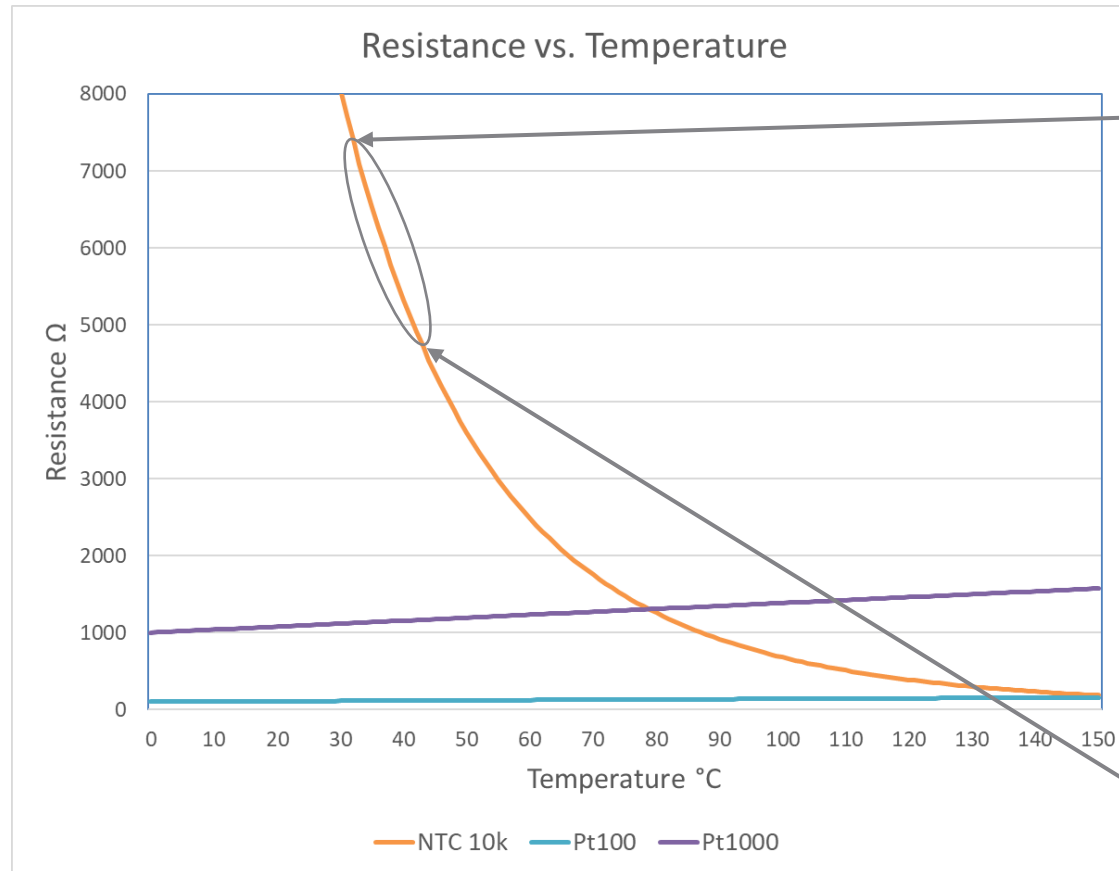
PATIENT MONITORING: PRECISION TEMPERATURE MEASUREMENT

Narrow operating temperature range

- +32 °C to +42 °C
- Large change in resistance over a short temperature range, but non-linear, even over a narrow temperature range:
 - $\Delta R_{32 \text{ to } 33 \text{ °C}} = 305 \text{ } \Omega / \text{°C}$
 - $\Delta R_{41 \text{ to } 42 \text{ °C}} = 191 \text{ } \Omega / \text{°C}$

High resolution / High precision

- Large ΔR combined with narrow operating temperature range enables high precision/accuracy over specified range:
 - $\pm 0.05, \pm 0.10, \text{ \& } \pm 0.2 \text{ } \text{°C}$



°C	KΩ
32	7.402
33	7.097
34	6.807
35	6.530
36	6.266
37	6.014
38	5.774
39	5.544
40	5.325
41	5.116
42	4.916

E-MOTOR APPLICATION: PUSH YOUR PERFORMANCE LIMITS

APPLICATION CONDITIONS



Wide Temp. Range

From -50 °C to +250 °C.



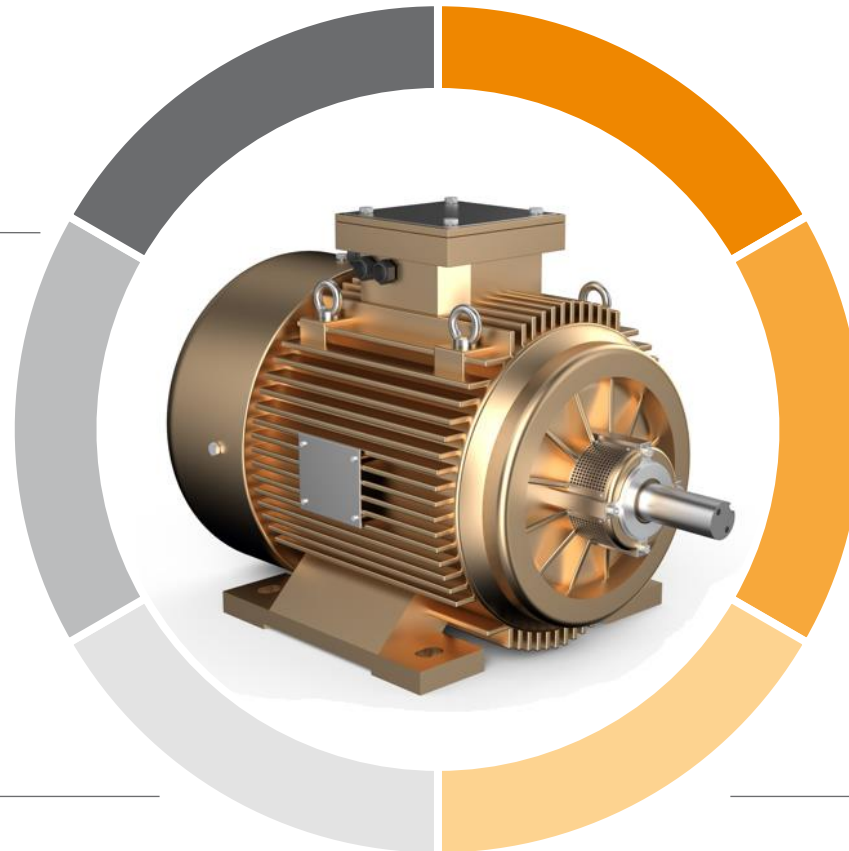
Hi-stress Temp. Cycling

In everyday use.



High Currents and Voltages

Up to 6 KV AC for 60 seconds as a requirement for the temperature sensor.



REQUIREMENTS FOR TEMPERATURE MEASUREMENT

Precise Temp. Measurement

To push the performance limits of an e-motor.



Reliable Temp. Control

To protect e-motors over the complete life cycle.



Fast Response Time

To protect windings and insulation from overheating.



E-MOTOR APPLICATION: TEMPERATURE CYCLE TEST TEST DOCUMENTATION

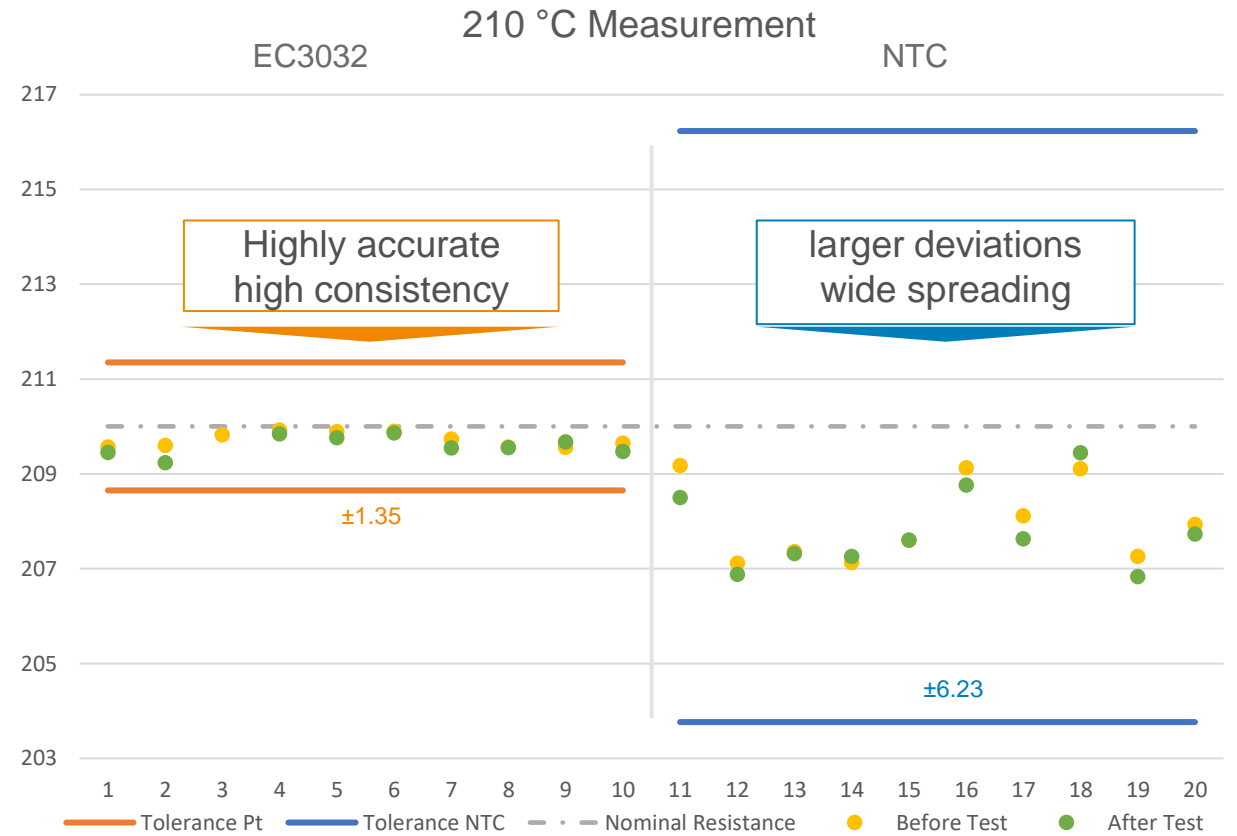
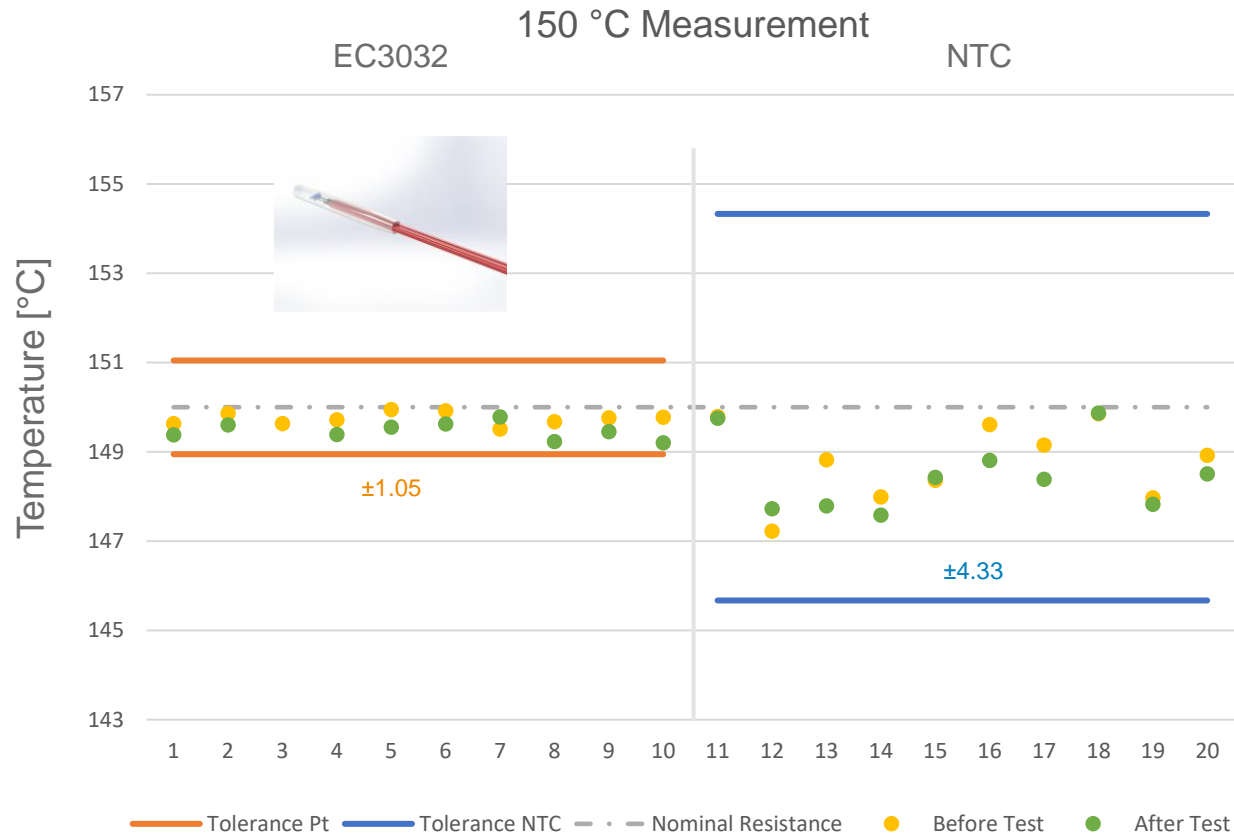
TEST SETUP

- Analysis before test:
0 °C, 100 °C, 150 °C, 175 °C, 210 °C
- Cycle shock test:
 - Temperature: warm 150 °C/ cold -50 °C
 - Dwell-time: warm 300 sec/ cold 300 sec
 - Numbers of cycles: 1000
 - Powered
- Analysis after test:
0 °C, 100 °C, 150 °C, 175 °C, 210 °C

SENSOR TYPES: WIRED 10X EACH

- EC3032 (Pt1000 M222 F 0.3)
- NTC motor sensor

TEMPERATURE CYCLE TEST: HIGHER PRECISION AND LOWER DRIFT FOR PT RTDS E-MOTOR APPLICATION



PT accuracy becomes even more apparent at higher temperatures

HEAT METERING: CONTROL OF COSTS

APPLICATION CONDITIONS



Narrow Temp. Range

0 °C to +40 °C.



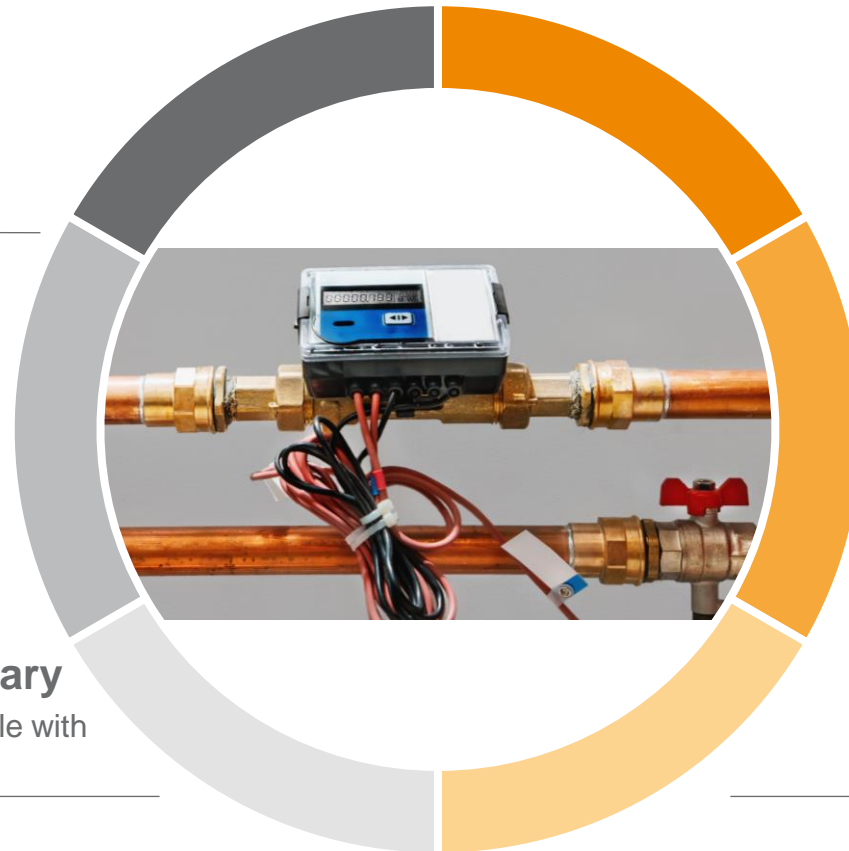
Large Scale Manufacturing

Needs to be installed in most Euro households.



Interchangeability is necessary

New product versions must be compatible with previous generation systems.



REQUIREMENTS FOR TEMPERATURE MEASUREMENT

Good Long-Term Stability

To ensure a long product lifetime.



Accurate Temp. Measurement

To ensure fair energy costs.

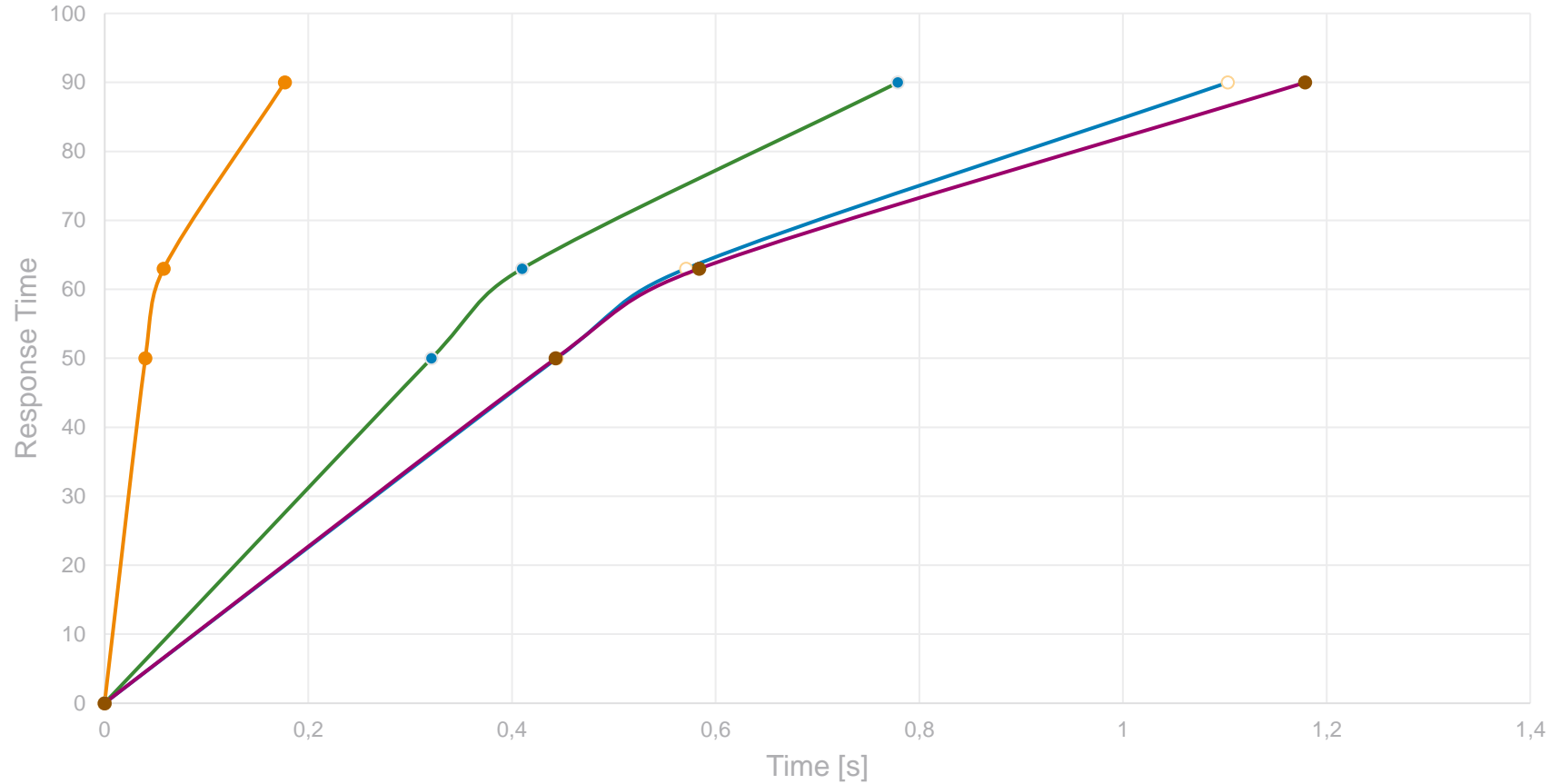


Fast Response Time

For traceable measurements.



FAST RESPONSE TIME FOR FAST REACTION TIMES



- HNE
- NTC Competitor 1
- NTC Competitor 2
- NTC Competitor 3



Median of 50 measurements

HNE	Comp.1	Comp. 2	Comp. 3
0.188 s	1.058 s	0.779 s	1.139 s

PCB SENSOR: SUPERIOR DESIGN FOR FAST RESPONSE TIME

Temperature range

-40 °C to +150 °C

Standardized dimensions

Ensures consistent part-to-part performance

Interchangeable

F 0.3 (± 0.3 °C @ 0 °C) accuracy, available tolerance grouping to 0.1 °C between 0 °C and 100 °C

Easy probe assembly

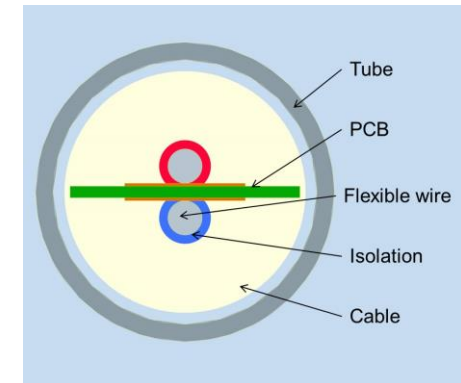
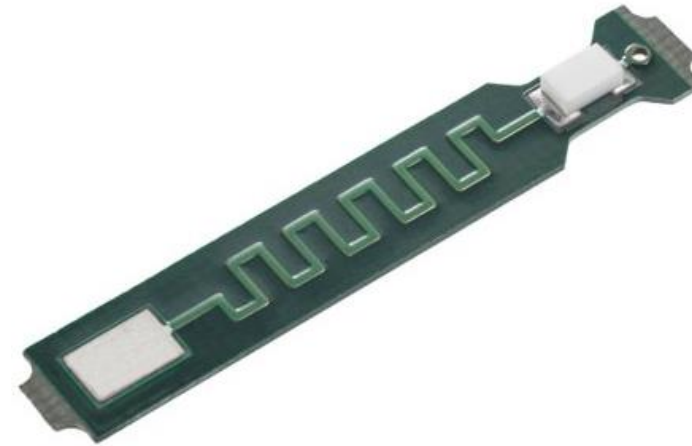
Dimensions matched to housing, easy lead attachment, no electrical isolation required

Accurate temperature measurement

Ensures accurate energy consumption billing

Heat break design

Provides thermal isolation and fast response to temperature changes



INDUSTRIAL CLOTHING IRON: PREVENTION OF CLOTHING DAMAGE

APPLICATION CONDITIONS



Wide Temp. Range

From +25 °C to +300 °C.



Excellent ironing results

Optimized temperature control for best results.



Short Heat-Up and Reaction Times

Powerful heating requires fast response times.



REQUIREMENTS FOR TEMPERATURE MEASUREMENT

Good Drift Behavior

Even after demanding temperature cycles.



Precise Temp. Measurement

Max. +/- 2 °C deviation over the complete temperature range.



Reliable temperature control

Over the complete life-cycle of the iron.



INDUSTRIAL CLOTHING IRON: TEMPERATURE CYCLE TEST TEST DOCUMENTATION

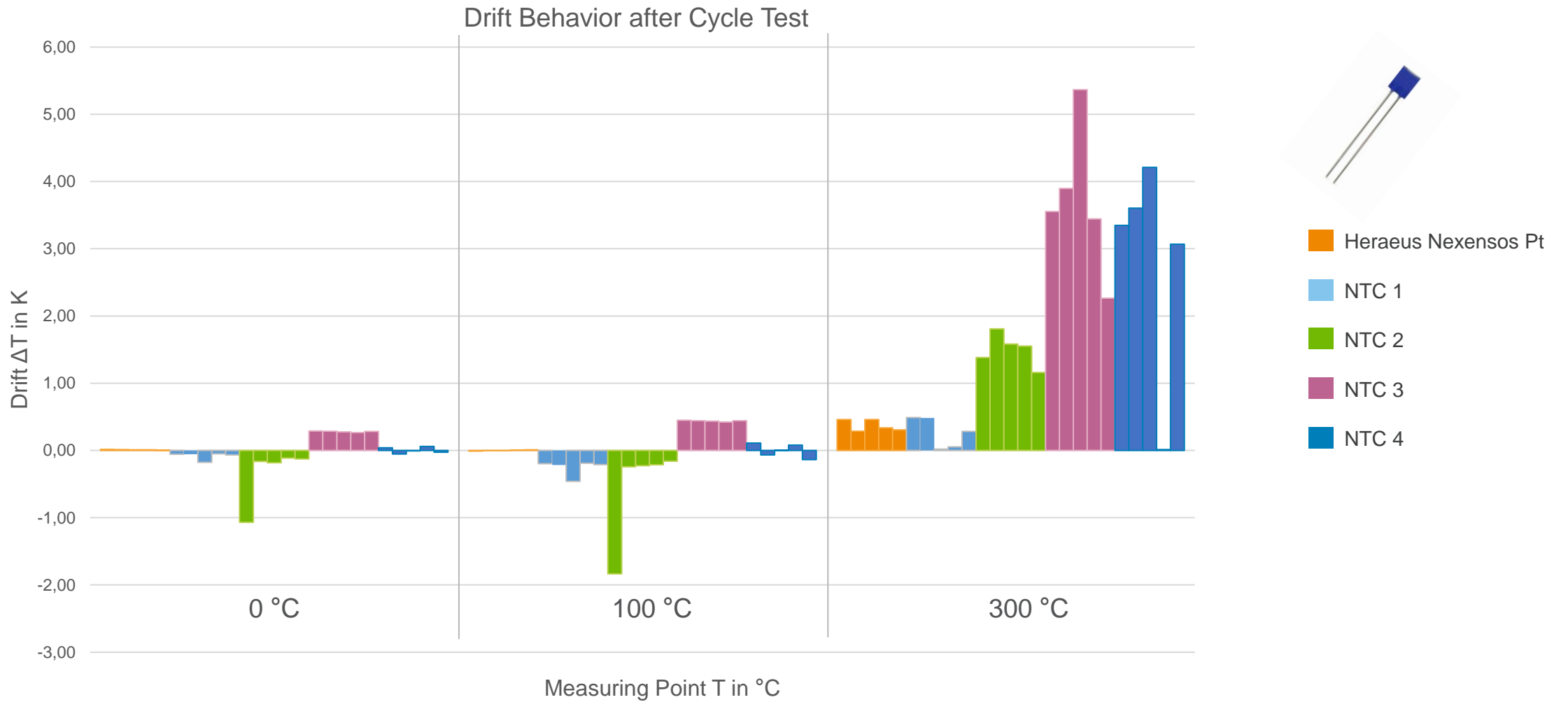
TEST SETUP

- Analysis before test:
R0, R100, R300
- Cycle shock test:
 - Temperature: warm 300 °C/ cold room temperature
 - Dwell-time: warm 60 sec/ cold 30 sec
 - Numbers of cycles: 1000
 - Powered
- Analysis after test:
R0, R100, R300

SENSOR TYPES: WIRED 5X EACH

- Pt1000 M222 F0.3
- 4 similar international NTC types
 - Specified for a temperature up to 300 °C
 - From leading NTC manufactures

GOOD DRIFT BEHAVIOR ALLOWS STABLE TEMPERATURE CONTROL



EXHAUST GAS MONITORING: HIGH ACCURACY IN HIGH STRESS CONDITIONS

APPLICATION CONDITIONS



Very Wide Temp. Range

From -40 °C to +1000 °C.



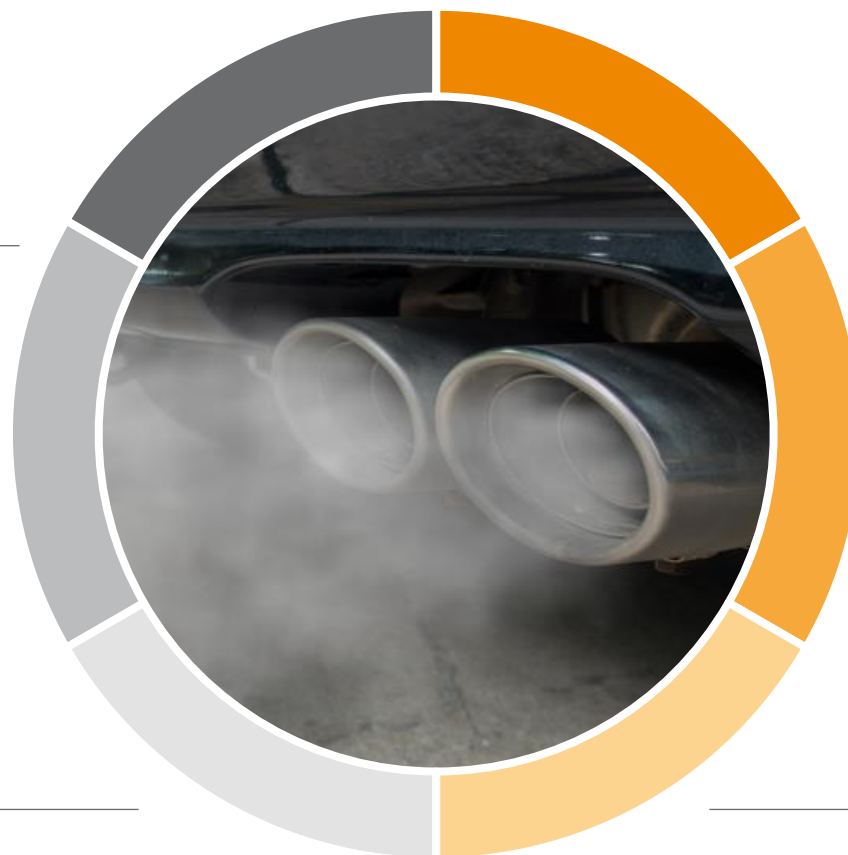
Rapid Temperature Change

Hundreds of degrees per second.



High Shock and Vibration

On- and off-road conditions.



REQUIREMENTS FOR TEMPERATURE MEASUREMENT

Robustness

Resistance to thermal shock, high temperature exposure, and shock/vibration.



Standardized Output

Industry standard-setting Pt200 sensor.



Long Life

Reduce costly vehicle downtime and maintenance costs.



EXHAUST GAS TEMPERATURE MONITORING



Very wide operating temperature range

- Exhaust system temperature can increase from ambient to +1000 °C in seconds during startup
- Water splash can reduce temperatures by hundreds of degrees nearly instantaneously



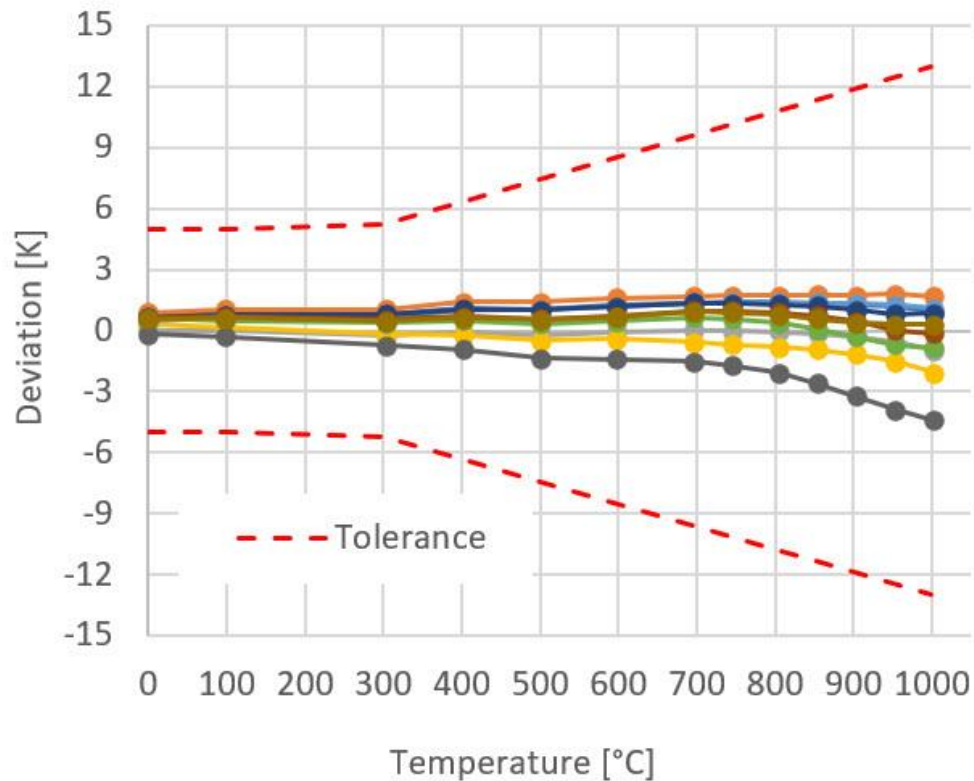
Proven tough design

- Sensor designed to withstand ΔT of over 1000K/sec, under vibration conditions of 55 to 5000 Hz, 100 to 400 ms^{-2} acceleration
- Superior manufacturing techniques
- Advanced material science



EXHAUST GAS TEMPERATURE MONITORING

RESULTS OF TEMPERATURE CYCLING TEST FOR HDZ420



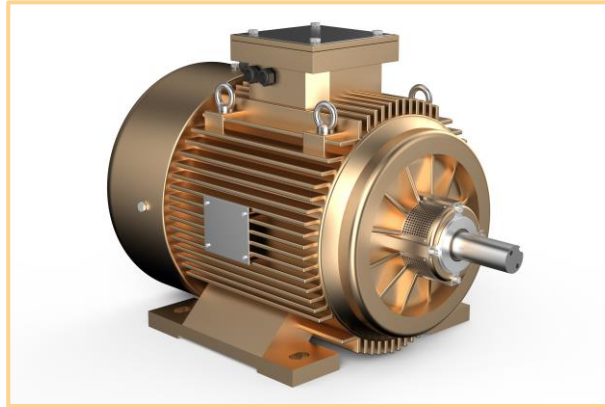
Test conditions:

5000 cycles between ambient and 1000 °C, well time 5 min each phase, powered with 5V, pullup resistor 1000 Ω

CHOOSE THE RIGHT TEMPERATURE SENSOR FOR YOUR APPLICATION!



BODY TEMPERATURE MONITORING



E-MOTOR



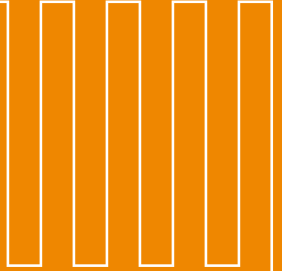
HEAT-METERING



INDUSTRIAL CLOTHING IRON



EXHAUST GAS TREATMENT



EXPERTS FOR MAXIMUM SENSING.