White Paper
ANTH-1 · Rev. A
June 2026 · www.analogtechnologies.com

Common Failures and Causes for NTC Thermistors

A practical guide to choosing, reading, mounting, and protecting glass and epoxy thermistors

Prepared for	Analog Technologies, Inc.
Document type	Improved educational white paper
Revision	Rev. A, June 2026
Source improved	ATI online white paper at analogtechnologies.com/white-paper/2015/1010/656.htm

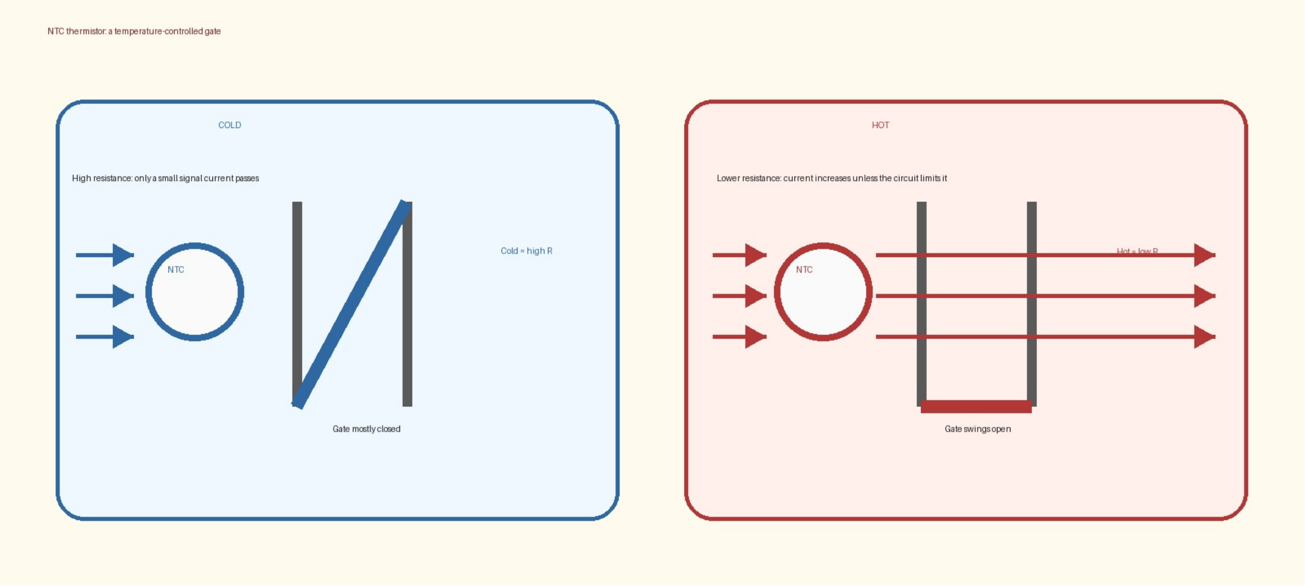


Figure 1. An NTC thermistor behaves like a temperature-controlled gate: cold means high resistance, while heat opens the gate and lowers resistance.

Abstract

An NTC thermistor is a small part with a large system responsibility. Electrically, it is only a resistor; thermally, it is a thermometer, a warning bell, and sometimes a tiny drama actor that can crack, drift, or burn if the circuit and mounting do not respect its limits. The most dangerous failure is not always the one that goes obviously open or short: a believable but wrong resistance can quietly mislead a battery, TEC, laser, medical, or industrial control loop. The previous short ATI online article correctly identifies short circuit, open circuit, and resistance offset; this version explains why those symptoms happen and how to prevent them.

This revised paper uses engineering formulas, verified manufacturer guidance, and cartoon analogies. The central message is simple: a thermistor is not merely a bead. It is a system consisting of a semiconductor ceramic, a protective body, a thermal path, a circuit, solder or leads, and process history. Exact R25, beta, tolerance, power, process, and temperature limits should always be confirmed from the controlled datasheet for the selected part.

1. What an NTC thermistor is really doing

An NTC thermistor is a thermally sensitive semiconductor resistor whose resistance decreases as its temperature rises [1]. Manufacturers use NTC thermistors for measurement, control, compensation, and protection, and ATI positions thermistor assemblies for industrial, medical, consumer, laser-diode, TEC-control, and battery applications [2]. The important point is that the part outputs resistance, not temperature; the circuit must translate resistance into temperature.

A useful mental picture is a parking-lot gate. When the thermistor is cold, the gate is stiff and mostly closed, so only a small electrical current can pass for a given voltage. When the thermistor is hot, the gate swings open, so resistance becomes lower. This is the opposite of a typical metal resistor, where resistance often rises with temperature.

$$\boxed{R(T) = R_{25} \times \exp[B \times (1/T - 1/298.15)] \text{ with } T \text{ in kelvin}}$$

Analog Devices explains that NTC thermistor resistance is strongly non-linear and that typical R25 values may range from tens of ohms to hundreds of kilohms, while typical beta values often fall in the 2500 K to 5000 K range [3]. Ametherm notes that beta is calculated from two temperature points and is useful for selection, but Steinhart-Hart modeling is more accurate across a wide range because it uses three temperature points [4].

Design term	Plain-language meaning	Why it matters
R25	Resistance at 25 °C	Sets the nominal resistance read by a divider or controller.
Beta, B	Curve steepness	Higher beta gives stronger resistance change per °C but over a narrower useful range.
Tolerance	How close one part is to another	Determines whether calibration is needed.
Dissipation factor	Power needed for 1 °C self-heating	Controls self-heating error.
Maximum power/current	Electrical safe operating boundary	Prevents thermal runaway, ceramic melting, or open/short failure.
Body material	Glass or epoxy protection	Determines temperature range, sealing, drift, cost, and mechanical behavior.

2. Glass and epoxy bodies: two common protective suits

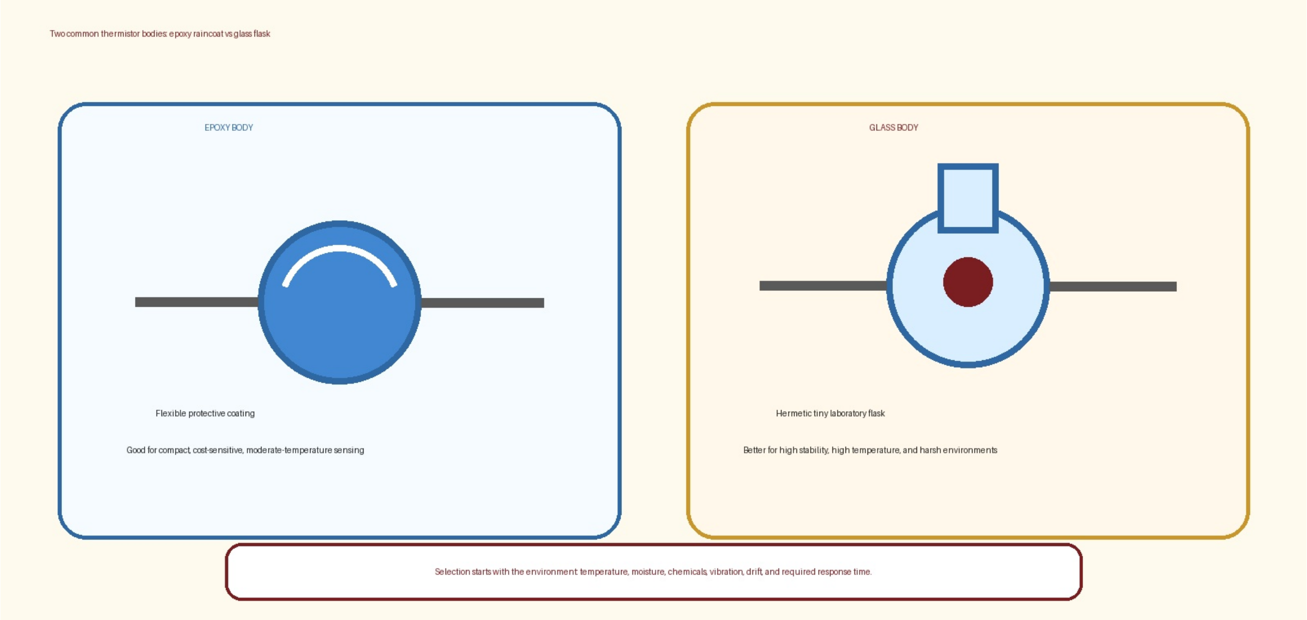


Figure 2. The thermistor body is commonly epoxy or glass. Epoxy is a practical wetsuit for moderate service; glass is a tiny hermetic hard-shell suit for harsher environments.

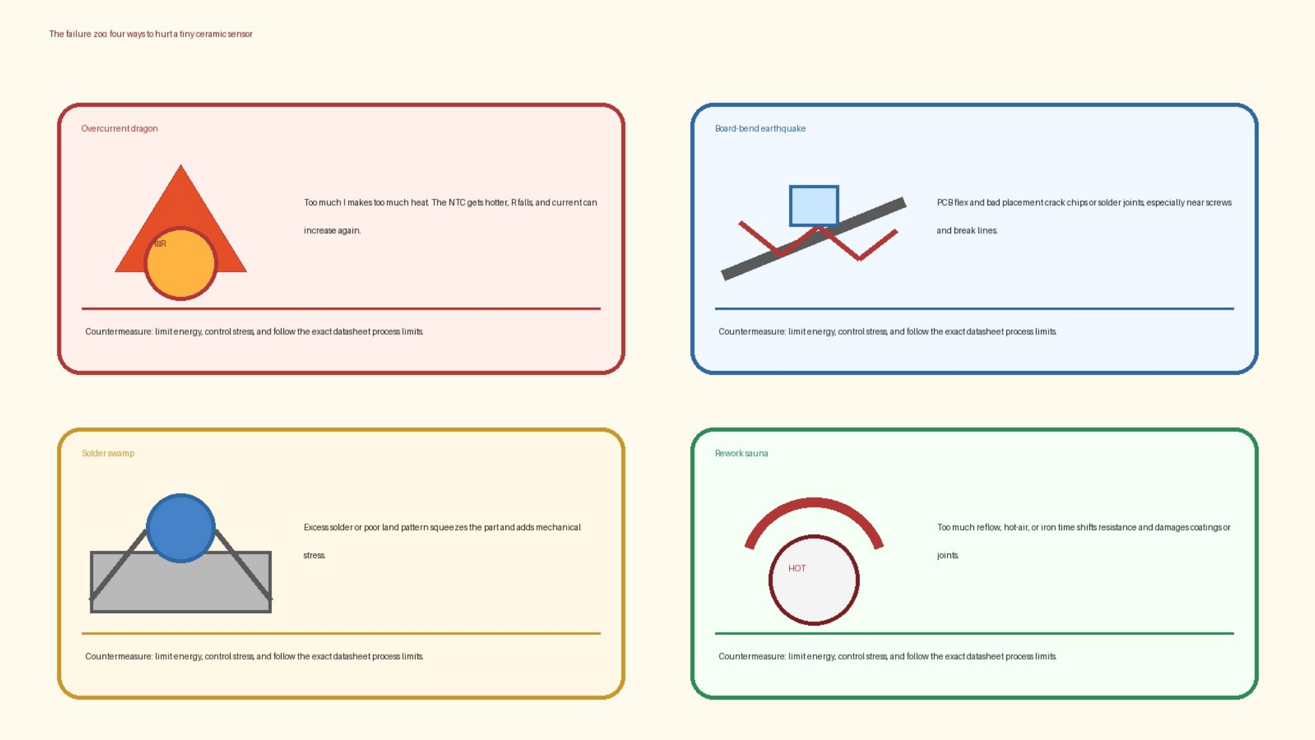
The body-construction point is important: the encapsulation is the shell around the sensing bead, and thermistor bodies are commonly offered in glass and epoxy forms. Both styles can protect the same basic NTC sensing concept, but the shell determines what the part can survive. ATI's thermistor product page emphasizes glass-encapsulated thermistors for long-term stability and wide temperature range, and the same ATI product family also includes epoxy-encapsulated thermistors [2]. Amphenol Thermometrics likewise lists both epoxy and glass NTC thermistor families [5].

Epoxy-coated NTC thermistors are often economical, compact, and fast. They are widely used in appliances, HVAC, batteries, medical probes, and general temperature sensing where the environment is moderate. Amphenol describes epoxy thermistor families as epoxy-coated chip thermistors for temperature measurement, control, and compensation, with common operating ranges such as –40 °C to 105 °C, –80 °C to 150 °C, or up to about 155 °C depending on series [5].

Glass-encapsulated thermistors use a glass body or bead package to protect the sensing element. Glass can provide hermetic sealing, excellent stability, voltage insulation, and improved survivability in high-temperature or harsh environments. Amphenol describes glass-packaged NTC chips as hermetically sealed and stable, while ATI notes low drift and wide operating temperature range for its precision glass thermistors [2] [5].

Body style	Cartoon analogy	Typical strengths	Watch-outs
Epoxy-coated	Flexible wetsuit	Low cost, small size, fast response, easy leaded assemblies	Check maximum temperature, moisture, chemicals, drift, and potting compatibility.
Glass-encapsulated	Hard-shell diving suit	Hermetic seal, high stability, high temperature capability, good for precision and harsh environments	Rigid bodies still need protection from point impact, lead stress, and mounting strain.

3. Why failures happen: not magic, just physics



Too much I makes too much heat. The NTC gets hotter, R falls, and current can increase again.

Countermeasure: limit energy, control stress, and follow the exact datasheet process limits.

PCB flex and bad placement crack chips or solder joints, especially near screws and break lines.

Countermeasure: limit energy, control stress, and follow the exact datasheet process limits.

Excess solder or poor land pattern squeezes the part and adds mechanical stress.

Countermeasure: limit energy, control stress, and follow the exact datasheet process limits.

Too much reflow, hot-air, or iron time shifts resistance and damages coatings or joints.

Countermeasure: limit energy, control stress, and follow the exact datasheet process limits.

Figure 3. Four villains in the thermistor failure zoo: overcurrent, board bending, solder stress, and rework overheating.

The older article states that excessive current, excessive power, instant energy, and excessive reflow or rework can cause short circuits, open circuits, and resistance offset. That is directionally correct, but the useful explanation is more specific: most failures come from electrical overheating, mechanical stress, process abuse, or environmental attack. In a properly biased 10 kΩ-class sensing divider, the current is usually tiny, so everyday field concerns are often cracking, drift, moisture ingress, solder stress, and rework damage. Burnout becomes realistic when the device is shorted to a supply rail, forced to dissipate too much power, or misapplied as an inrush-current limiter.

TDK identifies cracks and ceramic melting as practical failure modes in actual NTC thermistor use. Cracks can be caused by excessive solder or board stress after mounting. Ceramic melting can be caused by overcurrent and self-heating, especially because NTC resistance falls as temperature rises, allowing still more current if the circuit does not limit it [1].

The most dangerous loop is thermal runaway. It begins with current. Current creates power, $P = I^2R$ or $P = V^2/R$. Power heats the thermistor. For an NTC, heating reduces resistance. Lower resistance can increase current. The result is a small positive-feedback story: the thermistor says, ‘I am hot, so I will lower my resistance,’ and the circuit answers, ‘Great, now I can push even more current.’ Without a series resistor, current limit, or proper power rating, the part can burn, crack, short, or open.

Failure symptom	Likely cause	What is happening physically	Practical prevention
Open circuit	Surge energy, cracked body, broken lead	The electrical path breaks or ceramic/lead joint fractures.	Limit energy; support cables; avoid lead bending at the bead; respect process limits.
Short or very low resistance	Severe overheating or material damage	Internal material no longer behaves as designed semiconductor ceramic.	Add series resistance/current limit; observe maximum power and permissible current.

Failure symptom	Likely cause	What is happening physically	Practical prevention
Wrong but plausible drift	Rework overheating, aging, moisture, chemical ingress	R25 and the R–T curve shift, so the controller trusts a quiet lie.	Choose correct body; control rework; calibrate or sanity-check where accuracy requires it.
Intermittent reading	Board flex, cracked solder joint, lead fatigue	Connection opens only under vibration or bending.	Use correct land pattern, strain relief, and board placement.
Slow response	Wrong package or poor thermal coupling	The bead senses its package or air gap instead of the target.	Use thin adhesive, close mounting, and a good thermal path.

4. Do not confuse a sensing thermistor with an inrush-current limiter

This is one of the most common design mistakes. A sensing NTC thermistor is normally read with a small current so it measures the temperature of the object or environment. An inrush-current limiter is intentionally self-heated by large current so its resistance falls after turn-on. Both are NTC devices, but they have different missions.

The sensing thermistor is like a doctor holding a thermometer under a patient’s tongue. The doctor should not heat the thermometer with a lighter and then ask whether the patient has a fever. In the same way, a sensing circuit should not force enough current through the thermistor that the thermistor mainly measures its own self-heating. Analog Devices warns that current through the thermistor creates heat and causes the NTC resistance to indicate a temperature slightly above ambient unless the current is kept low [3].

Feature	Sensing NTC	Inrush-current NTC
Main job	Measure or compensate temperature	Limit turn-on surge current
Desired self-heating	As low as practical	Intentional and large
Typical circuit	Voltage divider into ADC/controller	Series element in the power input
Failure if misused	Bad readings, drift, or burnout	Overheating, high steady loss, or failure to reset
Design question	How do I read temperature accurately?	How much energy and steady current can the limiter survive?

5. The clean way to read an NTC thermistor

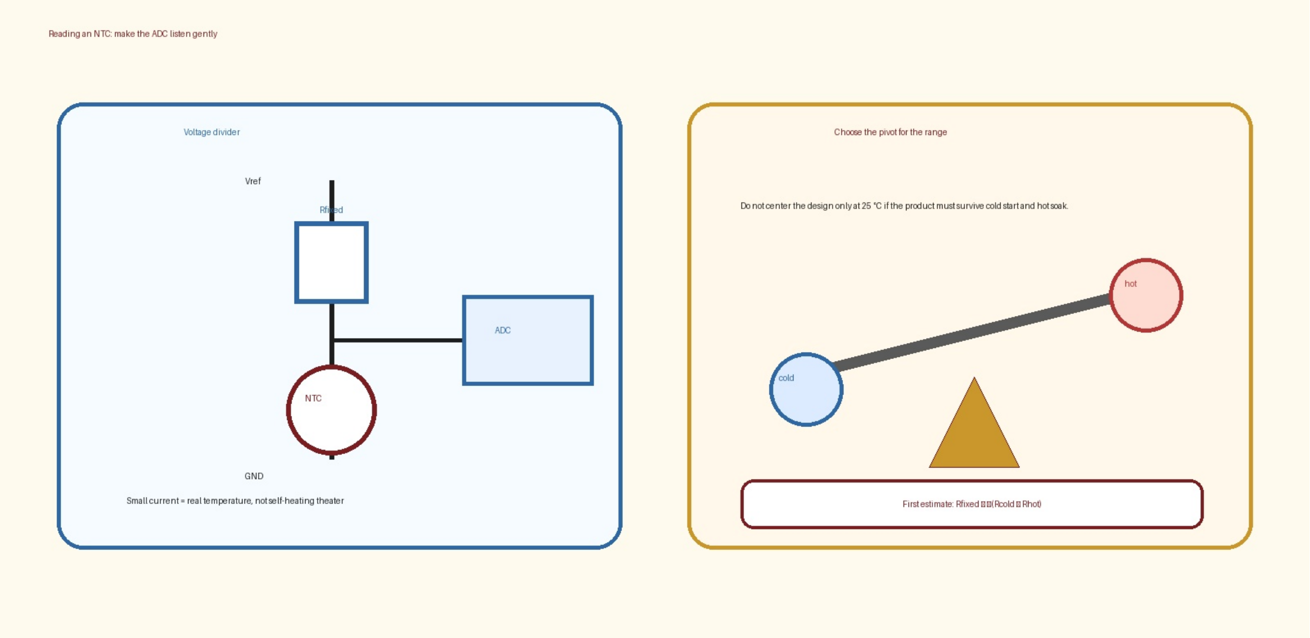


Figure 4. A thermistor divider should be read gently; the fixed resistor should be chosen for the actual hot-to-cold range, not by habit.

For most controllers, the thermistor is read as part of a voltage divider. Texas Instruments describes a common ADC sensing circuit in which an NTC thermistor and a fixed resistor form a divider. TI also notes that if the divider source is the same as the ADC reference supply, the measurement can be ratiometric, reducing sensitivity to reference variation [6].

A good first-pass divider resistor is not always exactly R25. TI recommends calculating the thermistor resistance at the hot and cold ends of the desired temperature range and choosing the fixed resistor approximately as the geometric mean of those two endpoint resistances [6]. This improves usable ADC range over the selected operating band.

$$R_{fixed} \approx \sqrt{(R_{hot} \times R_{cold})}$$

6. Thermal Ohm’s law: the hidden circuit around the thermistor

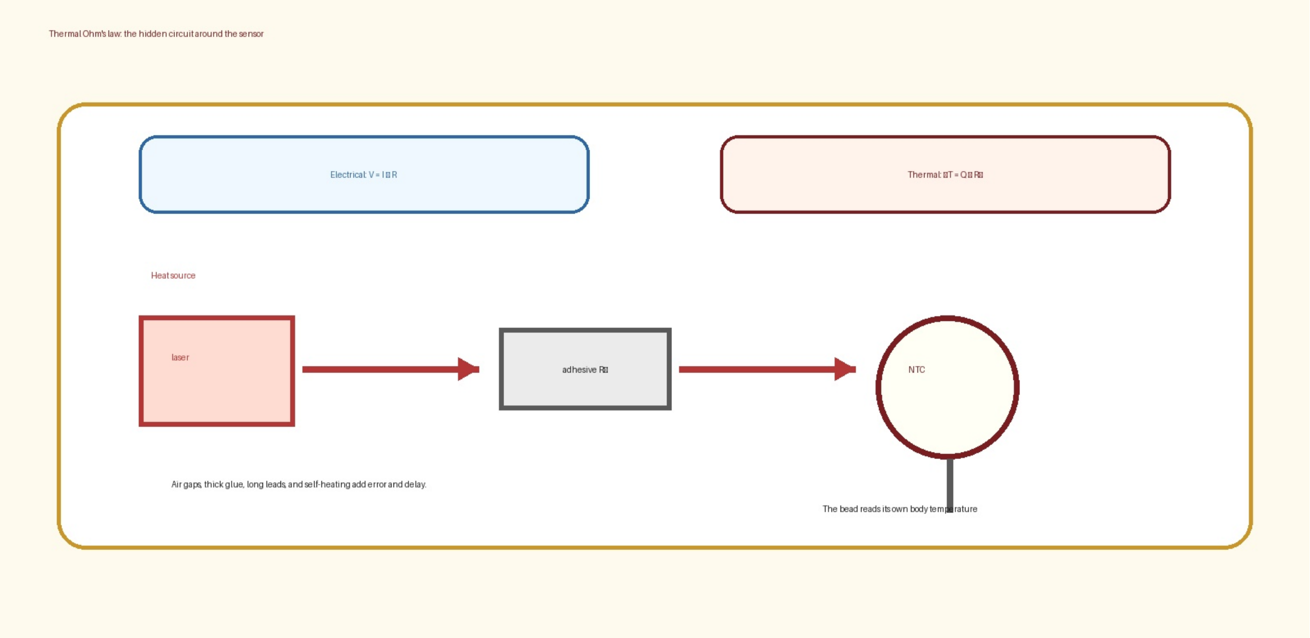


Figure 5. Thermal resistance is the hidden circuit between the heat source and the bead. The thermistor reads its own body temperature.

Electrical engineers already understand Ohm’s law: V = I × R. Thermal design has a similar structure. Temperature rise behaves like voltage rise, heat flow behaves like current, and thermal resistance behaves like electrical resistance:

$$\Delta T = Q \times R\theta$$

A thermistor attached to a laser diode, battery cell, heatsink, TEC cold plate, or motor winding does not read ‘truth.’ It reads the temperature of its own body. The body temperature equals the target temperature only if the thermal path is good and the self-heating is small. Thick adhesive, air gaps, long leads, and poor clamping create thermal resistance, which means the sensor is delayed and biased.

A practical rule is simple: make the thermistor small, put it close to the heat source, use a thin thermally conductive bond, strain-relieve the leads, and keep measurement power low. For high-precision temperature control, the mechanical interface is not packaging detail; it is part of the measurement circuit.

7. Mounting: many electrical failures start as mechanical abuse

TDK’s application note is especially useful because it emphasizes mechanical causes. Excessive solder increases stress on chip thermistors, while too little solder risks poor connection or dropout. TDK recommends using datasheet land patterns and controlling solder quantity [1]. TDK also shows that post-mounting board bending near split lines, screws, and impact points can crack an NTC chip, and that component orientation and distance from stress points matter [1].

For leaded glass or epoxy bead thermistors, the same concept appears as lead strain. The bead should not be used as a handle. Leads should be bent with tooling away from the bead, assemblies should have strain relief, and potting or adhesive should not create a rigid lever that transfers cable motion into the sensing element.

8. A better failure-analysis workflow

When a thermistor fails, do not start by blaming the part. Start by asking what story the failed part is telling. A shorted part often points to severe thermal or electrical abuse. An open part often points to cracking, lead fracture, or excessive pulse energy. A shifted part is the bathroom-scale failure: the instrument is still reporting a number, but that number has become biased by process overheating, long-term drift, moisture ingress, or chemical attack. An intermittent part often points to solder, board flex, or lead strain.

The best investigation pairs measurement with context. Measure resistance at 25 °C if possible, inspect the body under magnification, check solder fillets and land pattern, review reflow and rework history, calculate divider current and thermistor power at hot and cold extremes, and compare application current against the exact part’s datasheet ratings.

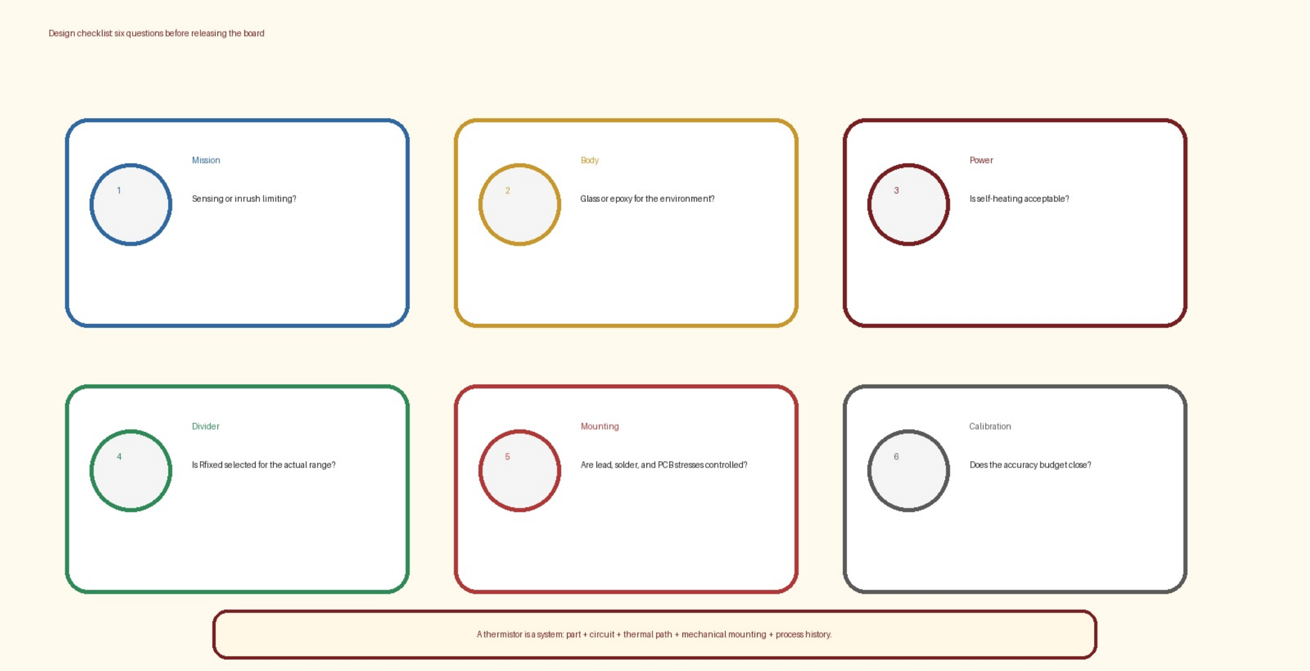


Figure 6. A thermistor release checklist prevents the same failure from returning in the next revision.

Question	Good answer
Is this part sensing temperature or limiting inrush?	The schematic, power level, and datasheet type all match the intended mission.
Did we classify the failure signature first?	Open, short/overheated, intermittent, and wrong-but-plausible drift lead to different root causes and fixes.
Did we verify glass versus epoxy body choice?	Glass is chosen for high stability, high temperature, or harsh conditions; epoxy is chosen for moderate temperature, cost, and assembly needs.
Is self-heating negligible for the accuracy target?	Divider current and thermistor dissipation are calculated at cold and hot extremes.
Is the fixed resistor chosen for the actual temperature span?	Rfixed is selected from endpoint resistance values or simulation, not habit.
Are solder and mounting stresses controlled?	Land pattern, solder volume, board flex, lead strain, and adhesive geometry are reviewed.

Question	Good answer
Are process limits respected?	Reflow, rework, soldering iron time, cleaning chemistry, and potting cure are inside supplier limits.
Is calibration needed?	Accuracy budget includes thermistor tolerance, beta tolerance, ADC error, resistor tolerance, self-heating, and thermal-interface error.

9. Conclusion

An NTC thermistor fails for understandable reasons. It is a temperature-sensitive semiconductor resistor protected by a body—commonly glass or epoxy—and connected to the outside world through solder joints, leads, adhesive, and circuit current. Treat it as a system, not as a magic bead. Use the right body material, keep sensing currents low, control thermal paths, prevent board and lead stress, and respect maximum power and process limits.

The result is not only fewer failures. The result is a temperature measurement that the controller can trust. In laser, TEC, medical, battery, and industrial products, that trust is the difference between a control loop that quietly protects the system and a control loop that confidently follows a false temperature into trouble.

References

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Document control

Item	Description
Prepared for	Analog Technologies, Inc.
Purpose	Replace and improve the online thermistor-failure note with clearer physics, verified glass/epoxy body guidance, practical design prevention, and educational cartoon figures.
Visual style	Header/footer and conservative technical layout inspired by the supplied ANHVPS-9 reference PDF.
Revision	Rev. A, June 2026