

Thermocouple *type comparison.*

Compare **J, K, T, E, N, R, S, B** thermocouple types — temperature ranges, accuracy, sensitivity, and color codes (US/ANSI and IEC/international). Picking the right type matters more than people realize.

The chart

TYPE	MATERIALS (+ / -)	RANGE (°C)	TOLERANCE	SENSITIVITY	NOTES
J	Iron / Constantan	-210 to 760	±2.2 °C or ±0.75%	~52 µV/°C	Sensitive, low-cost. Iron oxidizes – limited above 540 °C in oxidizing atmospheres.
K	Chromel (NiCr) / Alumel (NiAl)	-270 to 1372	±2.2 °C or ±0.75%	~41 µV/°C	Most common. Wide range, oxidation-resistant. The default 'general-purpose' thermocouple.
T	Copper / Constantan	-270 to 400	±1.0 °C or ±0.75%	~43 µV/°C	Best for cryogenic and low temperatures. Stable, accurate, good in moist environments. Limited to 400 °C.
E	Chromel / Constantan	-270 to 1000	±1.7 °C or ±0.5%	~68 µV/°C	Highest sensitivity of base-metal thermocouples. Good for low-temperature precision work.
N	Nicrosil / Nisil	-270 to 1300	±2.2 °C or ±0.75%	~36 µV/°C	Modern alternative to Type K. More stable at high temperatures , slower drift, more expensive.
R	Pt-13% Rh / Pt	-50 to 1768	±1.5 °C or ±0.25%	~10 µV/°C	Platinum-based, very accurate. Used in calibration labs, industrial high-temp. Expensive.
S	Pt-10% Rh / Pt	-50 to 1768	±1.5 °C or ±0.25%	~10 µV/°C	Similar to R, slightly less rhodium. Used as international temperature standard (ITS-90).
B	Pt-30% Rh / Pt-6% Rh	0 to 1820	±0.5% (above 800 °C)	~8 µV/°C	Highest temperature range. Insensitive below 50 °C. Used in glass and metal furnaces.

How thermocouples work. Two dissimilar metals joined at one end generate a small voltage (EMF) proportional to the temperature difference between the joined ('hot') end and the open ('cold' or reference) end. The voltage is on the order of microvolts per degree — typical 41 µV/°C for Type K. Modern instruments handle the cold-junction reference internally.

Common applications

APPLICATION	RECOMMENDED TYPE	WHY
Industrial process (general)	K	Wide range, low cost, universally available.
Cryogenic / liquid nitrogen	T	Accurate at very low temperatures; copper leg resists corrosion.
Food / pharmaceutical (low-temp)	T	Good in moist environments, FDA-acceptable copper leg.
High-temperature furnaces	R, S, B	Platinum-based for high-temp stability; B for above 1500 °C.

APPLICATION	RECOMMENDED TYPE	WHY
Engine exhaust temperature	K	Common in automotive; durable up to 1100 °C peak.
Calibration lab reference	S	International temperature standard (ITS-90).
Cement / kiln / glass furnace	B	Stable above 1500 °C where K/N degrade.
Laboratory low-noise work	E	Highest sensitivity = best signal-to-noise at low temps.
Long-term oxidizing environments	N	More stable than K above 1200 °C.

Common pitfalls

- **Yellow + Red = Type K in US, but Type K in IEC is Green + White.** The two color-code systems are mutually incompatible. Confirm which standard your country / supplier uses.
- **The magnetic-side trick for Type K.** Type K negative leg (Alumel) is magnetic; the positive leg (Chromel) is not. A small magnet near the lead distinguishes them — useful when colors are faded or ambiguous.
- **Cold-junction compensation matters.** A thermocouple only measures the *difference* between hot and cold ends. The cold (reference) junction must be at a known temperature, or compensated electronically. Modern DAQ systems do this automatically.
- **Thermocouple wire ≠ thermocouple extension wire.** 'Thermocouple-grade' wire is more accurate but expensive. 'Extension-grade' is cheaper and used between the thermocouple head and the measurement instrument — but it's only valid in a limited temperature range.
- **Drift at high temperatures.** Type K loses accuracy after long-term exposure above 1000 °C — the chromel leg can become 'green rot' from sulfur contamination, shifting calibration by several °C. Type N is more drift-resistant.
- **Insulation matters for the rated range.** A Type K rated 'to 1260 °C' may have PVC insulation rated only to 105 °C. The thermocouple itself can survive higher than its insulation. Use mineral-insulated or ceramic-insulated probes for high temperatures.

Common questions

Which thermocouple type should I use for my application?

Quick guide: Type K (general purpose, -200 to 1260°C, cheap, fine for most uses). Type J (iron/constantan, -210 to 760°C, vacuum or inert atmosphere). Type T (copper/constantan, -200 to 350°C, food and cryo). Type N (nicrosil/nisil, -270 to 1300°C, more stable than K). Type S, R, B (platinum-based, high temperature, expensive, precision).

Why does my Type K read 100°C when nothing is heating?

Common causes: missing cold-junction compensation (CJC), wrong extension wire (using copper instead of K-type alloy), broken probe with intermittent contact, or thermocouple amplifier set for the wrong type. Modern data loggers handle CJC automatically; older or DIY setups need to be checked.

How accurate is a Type K thermocouple really?

Stock Type K accuracy is $\pm 2.2^{\circ}\text{C}$ or $\pm 0.75\%$ of reading, whichever is greater, in the Class 2 (standard) grade. Class 1 is $\pm 1.5^{\circ}\text{C}$ or $\pm 0.4\%$. Calibrated against a reference (NIST-traceable), accuracy can be $\pm 0.5^{\circ}\text{C}$. For better than $\pm 0.5^{\circ}\text{C}$ accuracy you need Type S/R/B with proper calibration, not Type K.

Can I extend a thermocouple with regular copper wire?

Not without losing accuracy. Thermocouple wire produces voltage based on the temperature difference along the alloy. If you splice in copper wire, you create a new junction at the splice point. Use proper extension wire (Type K extension wire for Type K probes) all the way to the cold junction. The extension wire is cheaper than the high-temp wire.

What's the lifespan of a thermocouple?

Highly variable. In ideal conditions (low temperature, no chemicals): years to decades. At maximum rated temperature in clean air: months. In contact with sulfur, hydrogen, or oxygen at high temperature: hours to days. Drift becomes noticeable as the alloy contaminates. Inspect periodically against a reference; recalibrate as needed.

Sources

- **Thermocouple EMF tables and tolerance classes:** ASTM E230 / E230M (US) and IEC 60584-1 (international).
- **Color codes (US/ANSI):** ANSI MC96.1.
- **Color codes (IEC/international):** IEC 60584-3.
- **International temperature scale:** ITS-90 — defines temperature using Type S thermocouples and other reference instruments.

Disclaimer. Thermocouple selection should consider not just temperature range but atmosphere (oxidizing, reducing, vacuum), drift over service life, electromagnetic environment, and required accuracy. Consult an instrumentation engineer for critical applications.