THERMOCOUPLE SELECTION

Type E Nickel-Chromium vs. Copper-Nickel (Chromel † - Constantan)

This thermocouple develops the highest EMF/°C or °F of any of the thermocouples listed here. It is used in inert, oxidizing, or dry reducing atmospheres, protected or unprotected. A protected couple may be used in sulfurous and marginally oxidizing atmospheres. These thermocouples are not subject to corrosion in subzero atmospheres where there is a high moisture content and so are suited for such use. Type E thermocouples are recommended for use over the temperature range of -250 to 870°C (-418 to 1598°F). However, the upper temperature limit for .032" diameter size wire is limited to 540°C (1004°F). Smaller wire diameters are restricted to lower temperature limits; see table on next page.

Type J Iron vs. Copper Nickel (Iron-Constantan)

Fine wire Type J thermocouples are suitable for use in oxidizing, reducing, inert or vacuum atmospheres at temperatures up to 480°C (896°F). However, the iron oxidizes rapidly at elevated temperatures and wire sizes below .020" should not be operated above 370°C (698°F). Since the iron is subject to rust and embrittlement at subzero temperatures, it is not recommended for such use.

Type K Nickel-Chromium vs. Nickel-Aluminum (Chromel-Alumel)

Type K fine wire thermocouples may be used continuously in inert or oxidizing atmospheres at temperatures up to 649°C (1200°F) for .001" diameter bare wire, and up to 982°C (1800°F) for .032" diameter bare couples. These couples have better oxidation resistance characteristics than the other base metal thermocouples and so are widely used at temperatures above 540°C (1004°F). They may also be used temperatures as low as -250°C (-428°F). Type K thermocouples are not suitable for use in the following atmospheres: vacuums; sulfurous atmospheres without a protection tube; reducing, or oxidizing/reducing atmospheres without a protection tube.

Type R Platinum-13% Rhodium vs. Platinum
Type S Platinum-10% Rhodium vs. Platinum

Both Type R and Type S thermocouples may be used bare in clean, oxidizing atmospheres as long as no forced air flow is present, at temperatures up to 1400°C (2552°F) and intermittently up to 1750°C (3182°F). When properly protected they may be used continuously up to 1500°C (2732°F). If protected by nonmetallic protection tubes, such as high purity alumina tubes, these couples may be used in reducing atmospheres, or atmospheres containing metallic vapors or such volatile substances as zinc or lead. Neither Type R nor Type S thermocouples should be inserted directly into a metallic protection tube without first being inserted into a nonmetallic protection tube. Care should be taken to select a very high purity non-metallic protection tube so as not to contaminate the thermocouple.

Type T Copper vs. Copper-Nickel (Copper-Constantan)

Fine wire Type T thermocouples can be used in inert, reducing or oxidizing atmospheres to a maximum temperature of 150°C (302°F) for .001" diameter wires and up to 260°C (500°F) for .032" wires' Type T thermocouples are suitable for subzero temperature measurements and will resist corrosion in moist atmospheres. This is the most popular couple for subzero usage.

*LIMITS OF ERROR FOR THERMOCOUPLES

Reference Junction 0°C

Thermocouple Type	Temperature Range °C	LIMITS OF ERROR	
		Standard (whichever is greater)	Special (whichever is greater)
T	0 to 350	±1°C or ±0.75%	±.5°C or ±0.4%
J	0 to 750	±2.2°C or ±0.75%	±1.1°C or ±0.4%
E	0 to 900	±1.7°C or ±0.5%	±1°C or ±0.4%
K	0 to 1250	±2.2°C or ±0.75%	±1.1°C or ±0.4%
R or S	0 to 1450	±1.5°C or ±0.25%	±0.6°C or ±0.1%
B	800 to 1700	±.5%	—
T*	-200 to 0°C	±1°C to ±1.5%	**
E*	-200 to 0°C	±1.7°C or ±1%	**
K*	-200 to 0°C	±2.2°C or ±2%	**

* Thermocouples and thermocouple materials are normally supplied to meet the limits of error specified in the table for temperatures above 0°C. The same materials, however, may not fall within the sub-zero limits of error given in the second section of the table. If materials are required to meet the sub-zero limits, special materials must be ordered.

** Little information is available to justify establishing special limits of error for sub-zero temperatures. Limited experience suggests the following limits for Types E and T thermocouples:

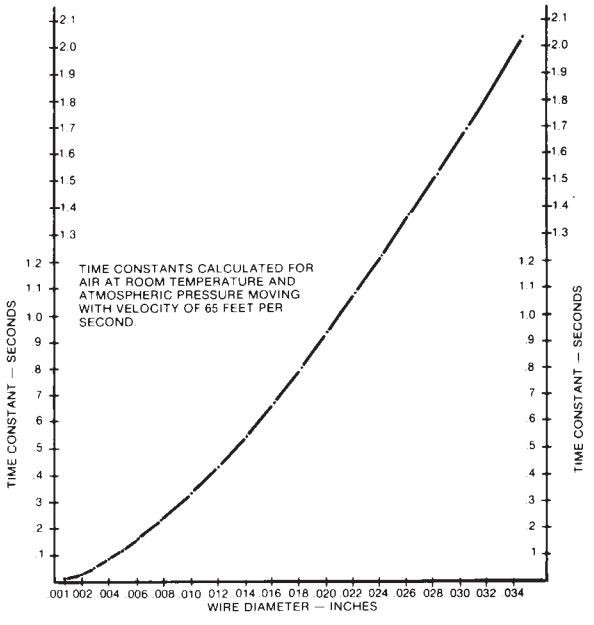
Type E -200 to 0°C ±1°C or ±0.5%
Type T -200 to 0°C ±0.5°C or ±0.8%

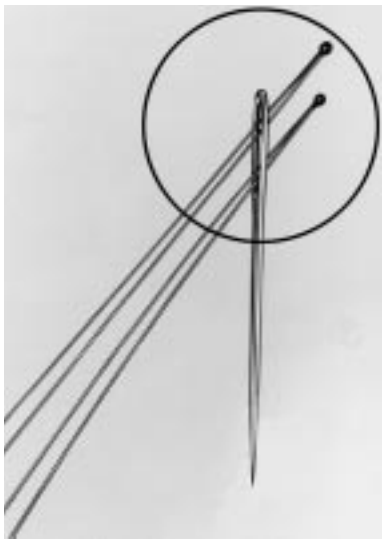
These limits are given only as a guide.

Due to the characteristics of the materials, sub-zero limits of error for Type J thermocouples and special sub-zero limits for Type K thermocouples are not listed.

† Chromel and Alumel are registered trademarks of the Hoskins Manufacturing Company.

THERMOCOUPLE TIME CONSTANT VS. WIRE DIAMETER





* RECOMMENDED UPPER TEMPERATURE LIMITS FOR FINE GAUGE,BARE WIRE THERMOCOUPLES AND THERMOCOUPLE WIRE (DEGREES F)

Type	.001	.002	.003	.005	.010	.015	.020	.032
E	600°F	650°F	700°F	800°F	800°F	800°F	800°F	1000°F
J	500	600	600	700	700	700	700	900
K	1200	1300	1400	1400	1400	1600	1600	1800
T	300	300	350	400	400	400	400	500
Chromel	1200°F	1300°F	1400°F	1400°F	1400°F	1600°F	1600°F	1800°F
Alumel	1200	1300	1400	1400	1400	1600	1600	1800
Constantan	600	650	700	800	800	800	800	1000
Iron	500	600	600	700	700	700	700	900

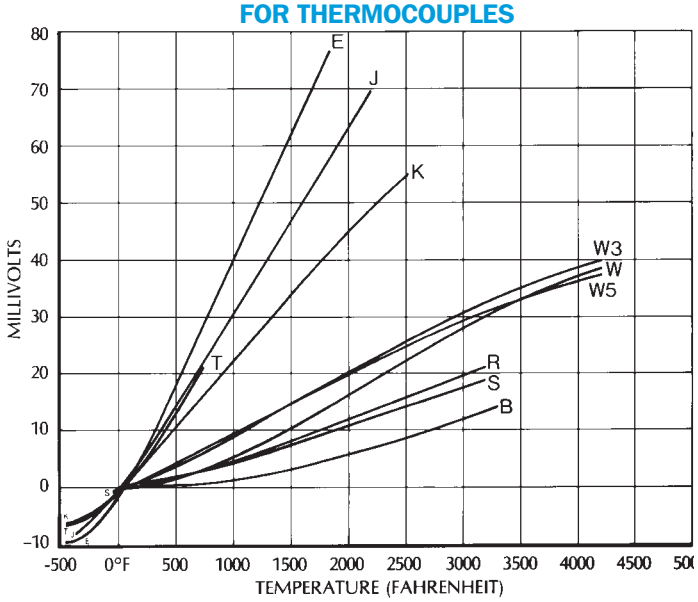
* Adherence to the temperature limits listed above will generally provide a satisfactory thermocouple life. In actual operation there may be instances where these limits may be exceeded for brief intervals. However, since we cannot control the environment in which they are used, the above recommendations cannot be taken as a guarantee of performance.

KEY TO SYMBOLS

E	Chromel - Constantan
J	Iron - Constantan
K	Chromel - Alumel
T	Copper - Constantan
B	Platinum 6% Rhodium vs. Platinum 30% Rhodium
R	Platinum vs. Platinum 13% Rhodium
S	Platinum vs. Platinum 6% Rhodium
W/W26/Re	Tungsten vs. Tungsten 26% Rhenium
W5Re/W26Re	Tungsten 5% Rhenium vs. Tungsten 26% Rhenium
W3Re/W25Re	Tungsten 3% Rhenium vs. Tungsten 25% Rhenium

Data sources: NBS Monograph 125 and Hoskins Manufacturing Company

TEMPERATURE-MILLIVOLT GRAPH FOR THERMOCOUPLES



WIRE SIZE VS. RESISTANCE FOR THERMOCOUPLE WIRE [RESISTANCE IN OHMS PER SINGLE FOOT AT 20°C (68°F)]

AWG	Diameter		Alumel (KN)	Chromel (EP, KP)	Constantan (EN, JN, TN)	Copper (TN)	Iron (JP)	Platinum (RN, SN)	Platinum 13% Rhodium (RP)	Platinum 10% Rhodium (SP)
	Inches	mm								
20	.032	.8818	.1729	.4155	.2871	.100	.0732	.063	.115	.113
24	.0201	.5105	.4381	1.052	.7277	.2541	1.856	.160	.293	.289
26	.015	.4049	.700	1.681	1.162	.4006	.2967	.284	.521	5.13
30	.010	.2548	1.77	4.25	2.940	1.026	.7500	.640	1.173	1.154
32	.008	.2019	2.766	6.641	4.594	1.0604	1.171	1.0	1.832	1.803
36	.005	.1270	7.08	17.0	11.76	4.106	3.0	2.56	4.692	4.616
40	.00315	.0799	17.838	42.832	29.63	10.34	7.56	6.45	11.824	11.633
44	.002	.0508	44.25	106.25	73.5	25.66	18.75	16.0	29.325	28.85
50	.001	.0255	177.0	425.0	294.0	102.67	75.0	64.0	117.3	115.4
56	.00049	.0124	737.193	1770.1	1224.5	428.51	312.37	266.56	488.54	480.63

Note: All resistances were calculated from data provided by the wire fabricators.

FINE GAUGE, BARE WIRE THERMOCOUPLES

Thermometrics manufactures fine gauge, bare wire thermocouples which offer faster, more precise temperature measurements than larger diameter thermocouples produced from like materials. Fine wire diameters respond more rapidly because thermal capacity is small.

In addition to speed and accuracy, fine gauge, bare wire thermocouples offer the benefits of a minimum disturbance to flow and temperature in the environment field in which they are introduced. Mechanical and thermal shock have minimal effects on thermocouples.

All of Thermometrics' thermocouples are made from matched pairs of wire and are supplied to fall within the *Standard Limits of Error for Thermocouples* established in the ANSI publication MC 96.1, 1975.

BASE METAL THERMOCOUPLES:

Type E Chromel-Constantan
Type J Iron-Constantan
Type K Chromel-Alumel
Type T Copper-Constantan

are supplied in the following diameters: .001", .002", .003",.005", .010", .015", .020", and .032" with a twelve inch immersion length, plus approximately 3/4 inch additional length for hook-up. Type E and Type K are also available in the ultra-fine gauge .0005" diameter with an eight inch immersion length, with approximately 1/2 inch for hook-up.

NOBLE METAL THERMOCOUPLES:

Type R Platinum-13% Rhodium vs. Platinum
Type S Platinum-10% Rhodium vs. Platinum

are supplied in diameters of .001", .002", .003", .005", .008", .010", .015", .020", and .032" with a six inch immersion length, with about 1/4 inch additional length for hook up.

APPLICATIONS:

Bare wire thermocouples are used in many fields:

Cryogenics
Medical Research
Biological Research
Gas Chromatography
Biophysics
Petrochemical Processing
Scientific Instrumentation
Chemical Research
Chemical Processing
Avionics
Nuclear Instrumentation
Paper Manufacture
Industrial Heating
Internal Combustion Testing

For ease of identification, the negative leg is always shorter than the positive leg.

All bare wire, fine gauge thermocouples are available as singles, or in our **ECONOMY FIVE PACK.** In the five pack each couple is individually mounted on a plastic strip which identifies the thermocouple type, wire diameter and immersion length. For protection and ease of handling the strips ar inserted into a padded plastic case.

NOTES:

All items listed are shipped from inventory.

Production quantities of thermocouples are available to manufacturers at O.E.M. pricing. Consult factory for details. Special sizes, and/or alloys are also available; contact factory for price quotation and delivery time.

CODING:

ANSI TYPE	Wire Components (Positive leg listed first)	Part Number	Wire Dia.	Immersion Length	ANSI TYPE	Wire Components (Positive leg listed first)	Part Number	Wire Dia.	Immersion Length
E	**Nickel-Chromium vs. Copper-Nickel (Chromel-Constantan)**	E-0005-5TC	0.0005	8 inches	**R**	**Platinum 13% Rhodium vs. Platinum**	R-001-5TC	0.001	6 inches
		E-001-5TC	0.001	12 inches			R-002-5TC	0.002	6 inches
		E-002-5TC	0.002	12 inches			R-003-5TC	0.003	6 inches
		E-003-5TC	0.003	12 inches			R-005-5TC	0.005	6 inches
		E-005-5TC	0.005	12 inches			R-008-5TC	0.008	6 inches
		E-010-5TC	0.010	12 inches			R-010-5TC	0.010	6 inches
		E-015-5TC	0.015	12 inches			R-015-5TC	0.015	6 inches
		E-020-5TC	0.020	12 inches			R-020-5TC	0.020	6 inches
		E-032-5TC	0.032	12 inches			R-032-5TC	0.032	6 inches
J	**Iron vs. Copper-Nickel (Iron-Constantan)**	J-001-5TC	0.001	12 inches	**S**	**Platinum 10% Rhodium vs. Platinum**	S-001-5TC	0.001	6 inches
		J-002-5TC	0.002	12 inches			S-002-5TC	0.002	6 inches
		J-003-5TC	0.003	12 inches			S-003-5TC	0.003	6 inches
		J-005-5TC	0.005	12 inches			S-005-5TC	0.005	6 inches
		J-010-5TC	0.010	12 inches			S-008-5TC	0.008	6 inches
		J-015-5TC	0.015	12 inches			S-010-5TC	0.010	6 inches
		J-020-5TC	0.020	12 inches			S-015-5TC	0.015	6 inches
		J-032-5TC	0.032	12 inches			S-020-5TC	0.020	6 inches
							S-032-5TC	0.032	6 inches
K	**Nickel-Chromium vs. Nickel-Aluminum (Chromel-Alumel)**	K-0005-5TC	0.0005	8 inches	**T**	**Copper vs. Copper-Nickel (Copper-Constantan)**	T-001-5TC	0.001	12 inches
		K-001-5TC	0.001	12 inches			T-002-5TC	0.002	12 inches
		K-002-5TC	0.002	12 inches			T-003-5TC	0.003	12 inches
		K-003-5TC	0.003	12 inches			T-005-5TC	0.005	12 inches
		K-005-5TC	0.005	12 inches			T-010-5TC	0.010	12 inches
		K-010-5TC	0.010	12 inches			T-015-5TC	0.015	12 inches
		K-015-5TC	0.015	12 inches			T-020-5TC	0.020	12 inches
		K-020-5TC	0.020	12 inches			T-032-5TC	0.032	12 inches
		K-032-5TC	0.032	12 inches					

THERMOCOUPLE WIRE KITS
12 SPOOLS

4 DIFFERENT KITS

Kit E	Chromer and Constantan
Kit J	Iron and Constantan
Kit K	Chromer and Alumel
Kit T	Copper and Constantan

6 WIRE SIZES IN EACH KIT

.001" diameter
.002" diameter
.003" diameter
.005" diameter
.010" diameter
.015" diameter

Thermometrics recognizes the needs of individuals in research, education and industry for small quantities of fine gauge thermocouple wire. These kits are designed to provide a comprehensive variety of wire sizes of the highest quality materials at a reasonable price. The wire can be used to form thermocouples that will fall within the ANSI "Limits of Error for Thermocouples"; provided they are produced using standard manufacturing practices. There are several excellent sources that delineate these practices; among them the ASTM publication #06-520077-40 "Standards of Thermocouples, 1978" and the Instrument Society of America publication " American National Standard for Temperature Measurement Thermocouples, MC96.1, 1975."

Protective cover mechanically protects wire, prevents wire snags, may be handled with ease!

CODING:

PART NUMBER	MATERIALS	ANSI TYPE	50 Feet of	WIRE DIAMETERS .001	.002	.003	.005	.010	.015
KIT-E	**Nickel-Chromium (Chromel)**	EP		X	X	X	X	X	X
	and								
	Copper-Nickel (Constantan)	EN		X	X	X	X	X	X
KIT-J	**Iron**	JP		X	X	X	X	X	X
	and								
	Copper-Nickel (SAMA Constantan)	JN		X	X	X	X	X	X
KIT-K	**Nickel-Chromium (Chromel)**	KP		X	X	X	X	X	X
	and								
	Nickel-Aluminum (Alumel)	KN		X	X	X	X	X	X
KIT-T	**Copper**	TP		X	X	X	X	X	X
	and								
	Copper-Nickel (Constantan)	TN		X	X	X	X	X	X

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PLATINUM RESISTANCE ELEMENTS

GENERAL INFORMATION

The resistance element is the temperature sensitive core of every resistance thermometer. Its characteristics, together with the method of housing, define the measuring capabilities of the thermometer.

CONSTRUCTION AND FUNCTION

The working part of a resistance element is a length of temperature sensitive platinum, in the form of a wire, a band or an etched thin film. This is housed either in a ceramic or glass cylindrical body or on a flat ceramic substrate respectively. The length of platinum is connected to two platinum connection leads which are also attached to the body with a vibration proof bond.

In elements containing two or more platinum sensing circuits, different lead lengths are used to differentiate the circuits.

The measurement principle is the change in electrical resistance with temperature (dR/dT). This function is the temperature coefficient and is set at 0.385 Ohm/K by IEC 751.

The resistance element records the average of the different temperatures to which it may be exposed along its length.

TOLERANCE AND LONG-TERM STABILITY

The basic values and tolerance classes of all the platinum resistance elements described in the data sheets are according to the IEC 751 standard.

This IEC standard set definitions for tolerance classes IEC B and A in a temperature range from -200°C to +850°C. Narrower tolerances in restricted temperature ranges, offered by Thermometrics are a proportional restriction of class B (class 1/a B: $\Delta t = \pm 1/a\ (0.3 + .005\ [t])$.

The IEC data are valid for nominal resistance values of 100 Ohms. For resistance elements with the nominal value n x 100 Ohms, the basic values and tolerances also have to be multiplied by n.

The long-term stability of the resistance elements meet or exceed the IEC requirements.

MEASURING CURRENT AND SELF-HEATING

Resistance elements heat up slightly when current is flowing through them. The maximum measuring current is determined by the thermal contact between the resistance element and the medium to be measured and also by the thermal coefficient of the medium. A resistance thermometer used in flowing water will, for example, tolerate a considerably higher measuring current than a similar thermometer in air, assuming the same self-heating error.

In practice, measurement conditions vary widely, therefore theoretical recommendations on the measuring current are avoided. Instead, the self-heating coefficients for each resistance element type are listed.

For a given measuring current this self-heating coefficient can be calculated by means of the formula:

$$\Delta T = P \times S$$

when: ΔT = self-heating in Kelvin

$P = I^2R$, power consumed in mW

S = self-heating coefficient in k/mW

These resistance elements can be used for A.C. and D.C. measurements.

The thin film elements are free from induction.

RESPONSE TIME

50% response time is the time it takes a thermometer to record half of the value of a temperature source. 90% response time is defined similarly. These two values are stated for water with 0.4 m/s stream velocity and for air with 1 m/s velocity. They can be calculated for every medium with a thermal conductivity value defined by VDI/VDE 3522.

HYSTERESIS

At specific temperatures, resistance values can deviate from their original value after having run through a complete temperature cycle, such as cooling down and reheating. This phenomenon is called hysteresis.

The alterations in the measured values can be eliminated or compensated for the opposite temperature cycle. Hysteresis is also caused by temperature shocks.

CHOICE AND INSTALLATION OF RESISTANCE ELEMENT

In order to guarantee correct temperature measurement with platinum resistance elements it is necessary to adapt the mechanical and technical characteristics of the resistance element, such as size, shape, vibration resistance, insulation resistance and response time, to the measurement task and location. Of equal importance to the choice of resistance element is the housing of the element in the thermometer and the installation of the thermometer. For expert advice in the area, please contact our experienced application engineers.

ASSEMBLY INSTRUCTIONS

Connection of all resistance elements is possible by welding, soldering or brazing. Flux residues should be removed.

STANDARD PROGRAM AND DELIVERY

Different versions of resistance elements are available in our standard program. For special applications, requiring other dimensions, tolerances and electrical connections, please contact our sales representative.

TOLERANCES AS A FUNCTION OF TEMPERATURE FOR 100 OHMIC PLATINUM RESISTANCE ELEMENTS

Tolerances of basic values for platinum resistance elements are defined by IEC 751 as follows:

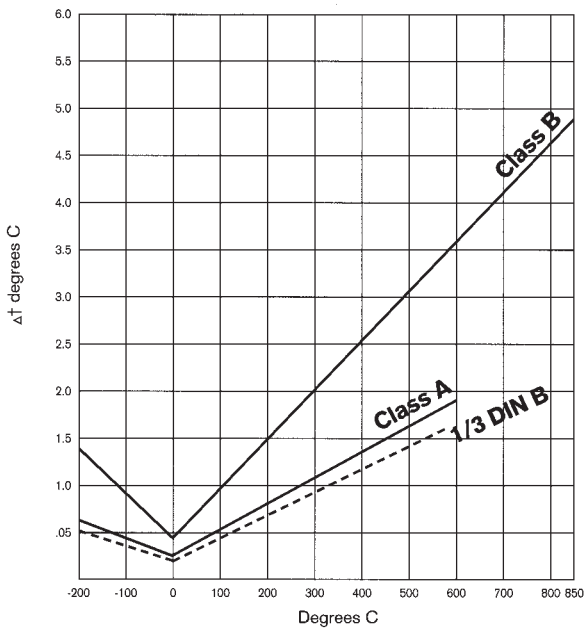
Class B: $\Delta t = \pm(0.3 + 0.005[t])$

Class A: $\Delta t = \pm(0.15 + 0.002[t])$

Narrower tolerances offered by Thermometrics are a mathematical restriction of class B:

Class 1/aB: $\Delta t = \pm 1/a(0.3 + .005[t])$
in which [t] = absolute temperature in °C.

For resistance elements with the nominal value n x 100 Ohms, the basic values and tolerances also have to be multiplied by n.



Degrees Celsius	Basic values according to IEC 751		Tolerance according to IEC 751			
			Class A		Class B	
	Ohms	Ohms/K	Ohms	°C	Ohms	°C
-200	18.49	0.44	±0.24	±0.55	±0.56	±1.3
-100	60.25	0.41	±0.14	±0.35	±0.32	±0.8
0	100	0.39	±0.06	±0.15	±0.12	±0.3
100	138.5	0.38	±0.13	±0.35	±0.30	±0.8
200	175.84	0.37	±0.20	±0.55	±0.48	±1.3
300	212.02	0.35	±0.27	±0.75	±0.64	±1.8
400	247.04	0.34	±0.33	±0.95	±0.79	±2.3
500	280.9	0.33	±0.38	±1.15	±0.93	±2.8
600	313.59	0.33	±0.43	±1.35	±1.06	±3.3
700	345.13	0.31			±1.17	±3.8
800	375.71	0.30			±1.28	±4.3
850	390.26	0.29			±1.34	±4.6

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