THERMOCOUPLE SET
DESCRIPTION D053

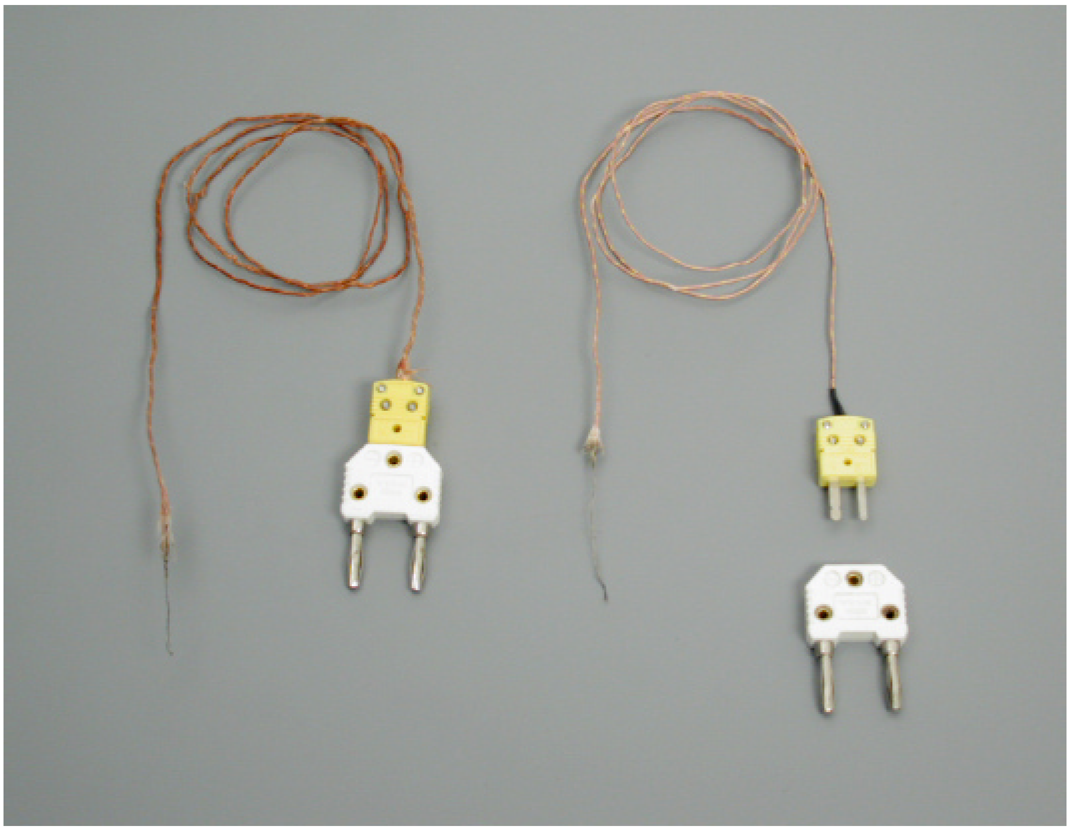


Figure 1. Thermocouple set

Short description

The thermocouple set consists of:

- two thin Chromel™[1] (chromium - nickel) and Alumel™ (aluminum - nickel) thermocouples (0.25 mm),
- two thicker thermocouples (0.51 mm),
- two plugs for the thermocouples, and
- two adapters for connection to the signal amplifier.

At every transition between two materials, there is a contact potential. This potential is dependent upon the two materials, which are in contact with each other, and is dependent upon the temperature. This phenomenon is used by the thermocouple set.

The thermocouple set is delivered with adapters for connection to the CMA Signal Amplifier (011) and can be connected through the Amplifier to the following interfaces:

- UIA/UIB board
- CoachLab (via 0519 adapter)
- CoachLab II
- SMI
- Texas Instruments CBL™ data-logger (via 0519 adapter).

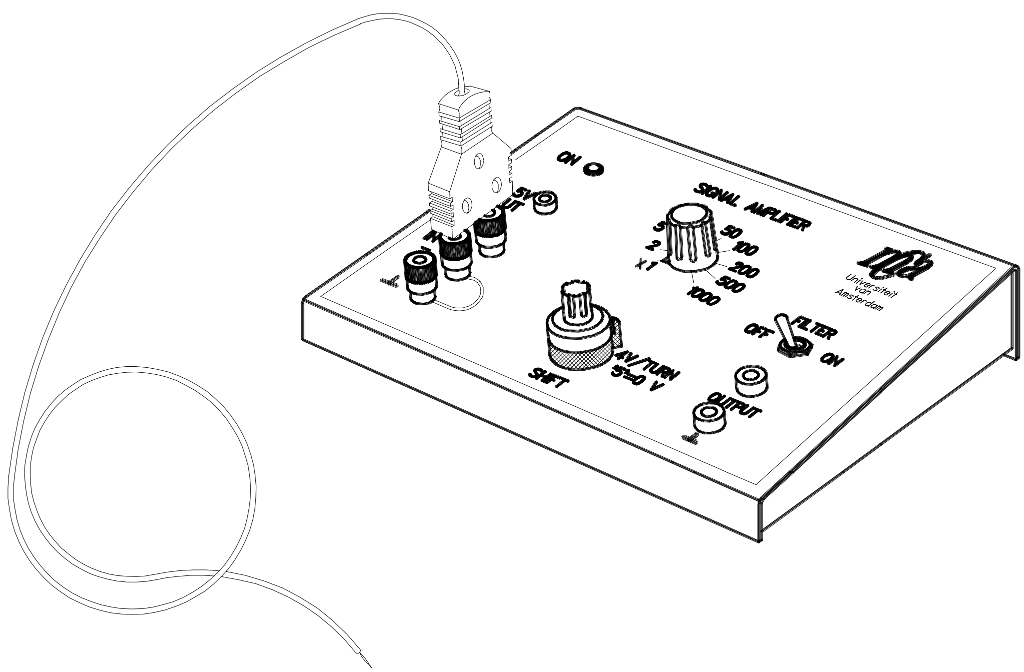


Figure 2. Thermocouple connected to the Signal Amplifier.

[1] Chromel™ - Alumel™ are registered trademarks of HOSKINS, Hamburg USA

Suggestion for experiments

- Measurements of the temperature inside a Bunsen burner flame or candles.
- Measurement of breath.
- Experimentally determine the melting point of copper, bismuth, or other solids.

Measuring without a reference thermocouple

Simple use of the thermocouple set is shown in figure 3. A Chromel™ wire and an Alumel™ wire are welded to each other. The other ends of wires are connected to pins of a plug, which are also made of Chromel™ and Alumel™, so that these connections don't give rise to a total contact potential.
When the plug goes into adapter, there is a contact potential as well between Chromel™ and Copper as between Alumel™ and Cooper. This gives a net contact potential between Chromel™ and Alumel™.
If the thermocouple junction and adapter have the same temperature, then the potentials exactly cancel and there is no output voltage.
If the temperature of the thermocouple junction is higher then the contact potential is also higher and so there is a net potential. The thermal voltage is thus an indication of the difference of temperature between the thermocouple and its connectors.

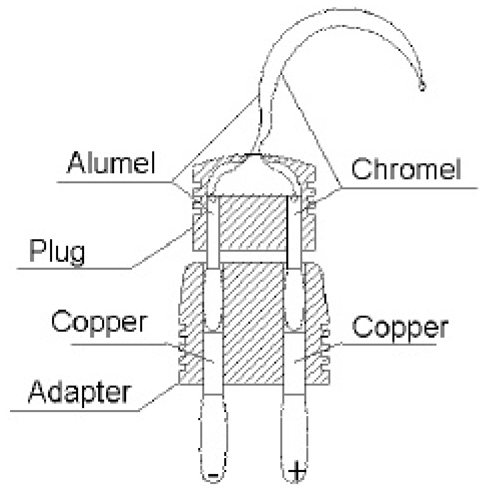


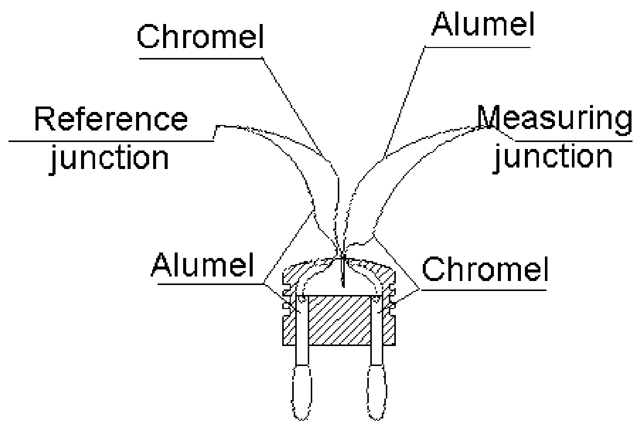
Figure 3.
Connection of the thermocouple without reference thermocouple.

For practical purposes we can consider that we are measuring the temperature relative to room temperature. The advantage of this method is its simplicity. This method is useful when the room temperature remains reasonably constant. In other cases a reference thermocouple must be used.

Measuring with a reference thermocouple

More accurate measurement is possible by ensuring that the transition within the circuit outside the thermocouple is at a known temperature. An effective solution is shown on the next page.
Using two thermocouples, you connect both the Alumel™ wires and insulate the connection.

The Chromel™ wires are fitted to the connector. One of the thermocouples is used as a reference.
(The fact that there are various transitions between metals with its own contact potential is no longer a problem. Provided that the temperature within the connector is constant, these potentials cancel each other.)



If the reference thermocouple is placed in melting ice, the potential of the other thermocouple indicates its temperature relative to 0ºC.

The sensitivity

The thermal potential relative to a reference at 273ºK can be found in standard tables and is shown in the figure 4.

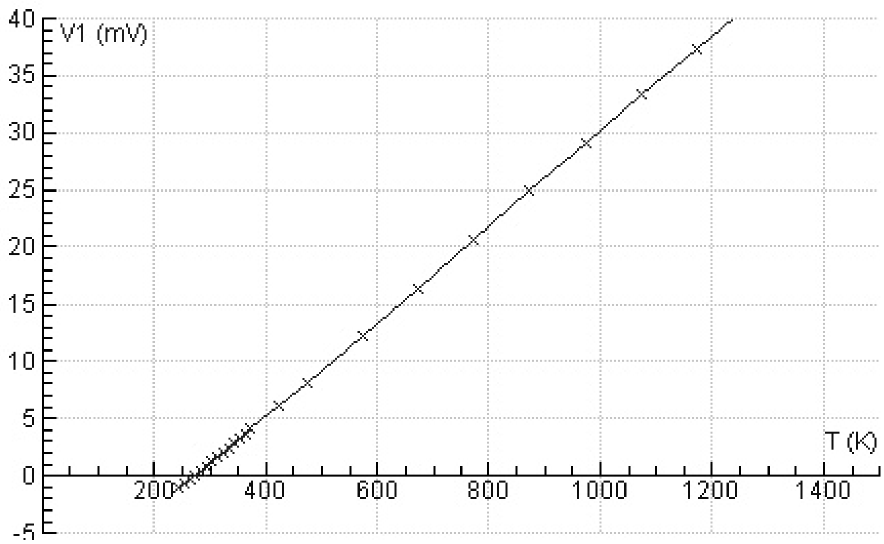


Figure 4. The thermal potentials relative to a reference at 273ºK

Figure 5 shows the sensitivity of the thermocouple as a function of temperature. It is apparent that the sensitivity is not constant, although the variation is small. At room temperature the sensitivity is 0.040 mV/K.
At 100ºC, 0.041 mV/K.

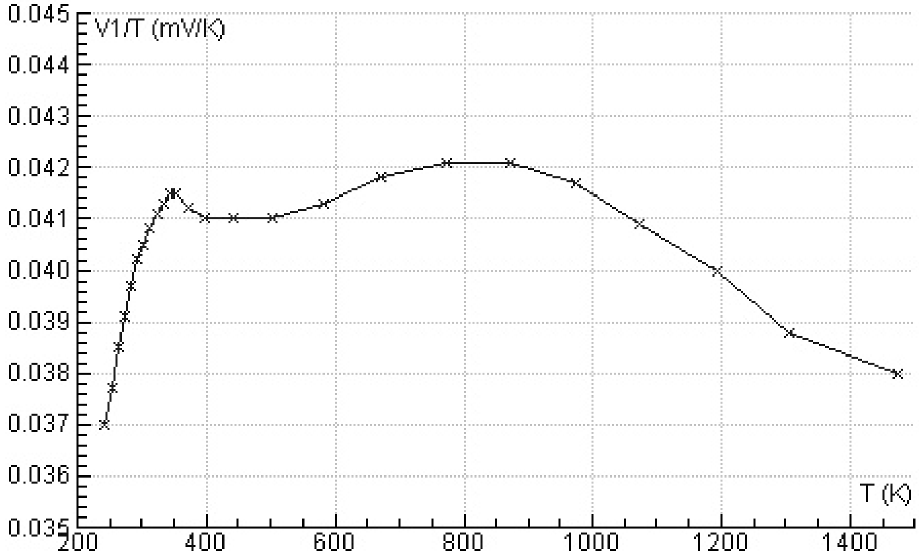


Figure 5. Sensitivity of the thermocouple as a function of temperature

Range and resolution

The potentials that must be measured are small therefore the signal amplifier (art. nr. 011 see Figure 2) is essential.
The temperature range can be chosen by varying the amplification.
The amplifier offset can be used to move the range along the scale.
Table shows the range of the thermocouple with various amplifications. The resolution is also shown.
The table assumes use of the interface with 12-bits analog to digital converter. The table is based on a sensitivity of 0.040 mV/K, at higher temperatures this can lead to an error of 2.5 %.

Amp. Factor	Range (0-5V) (K)	Reso-lution (K)
100	1250	0.61
200	625	0.31
500	250	0.13
1000	125	0.06

Calibration

If high accuracy is not required, the thermocouple set can be used without a reference thermocouple. The sensitivity is not constant, but the variation is not large. A linear calibration is usually sufficient.
If you wish to make measurements, which are not subject to a systematic error, then a calibration must be used. Data from standard tables can be used taking the amplification into account.

In the sensor library of Coach 5 program the following sensors are available (calibrated for different amplification factors):

- **Thermocouple (053) (100x)(CMA) (0..1250^{0}C)**
- **Thermocouple (053) (200x)(CMA) (0..625^{0}C)**
- **Thermocouple (053) (500x)(CMA) (0..250^{0}C)**
- **Thermocouple (053) (1000x)(CMA) (0..125^{0}C).**

Measuring rapid temperature change

The rate at which the thermocouple takes on the temperature of its environment is difficult to predict precisely, because it depends on a large number of factors. However it is possible to give a rule of thumb. If the thin thermocouple is allowed to cool in reasonably still air, within 3 seconds its temperature will fall so that the difference with room temperature is reduced to 36.5 %. In the case of the thick thermocouple, this will require 8 seconds.
In air, the thin thermocouple will fall from 20ºC above room temperature to room temperature in about 15s The thicker thermocouple takes about 35s. In a liquid the temperature will be followed almost directly.

Technical data

The thermocouples are insulated with glass fibber braid. The Chromel wire is in yellow insulation (positive), and the Alumel wire has reddish insulation (negative). The thermocouple gives a positive potential difference when its temperature is higher than reference, which is usually room temperature. The wires are about one meter long. The plug has a Chromel and an Alumel pole, to prevent contact potentials in the plug. No compensation is provided within the connectors.
A Chromel™-Alumel™ thermocouple has a typical range of -200ºC to 1260ºC. For long measurements, the maximum temperature is limited to 880ºC. The insulation is damaged when working above 480ºC, but this does not normally detrimentally influence the operation of the thermocouple. The thermocouple may be damaged if it is used in the presence of sulfur, or under reducing conditions.
Use in a vacuum can not be guaranteed, because the calibration can become invalid.

Diameter Length	Thin: 0,25 mm; Thick: 0,51 mm 91 cm
Insulation	Braided glass fiber
Metals	Chromel™ - Alumel™
Sensitivity	Approximately 0.04 mV/K, see standard tables for full details
Temperature range	73 K to 1530 K. Maximum for long measurements 1050ºK. Sheathing to 750ºK without damage.
Limitations	Can be damaged by reducing conditions, or sulfur. Not suitable for long use in a vacuum.
Speed Thin Thick:	 In air: 3 s for a 63% change towards the temperature of the environment; In liquid: 0.1 s as above In air: 8 s as above In liquid: 0.1 s as above.
Parts	- 2 thin thermocouples - 2 thick thermocouples - 2 compensated thermocouple plugs - 2 connectors to standard stackable banana plugs, not compensated.

[1]Chromel™ - Alumel™ are registered trademarks of HOSKINS, Hamburg USA

This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

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