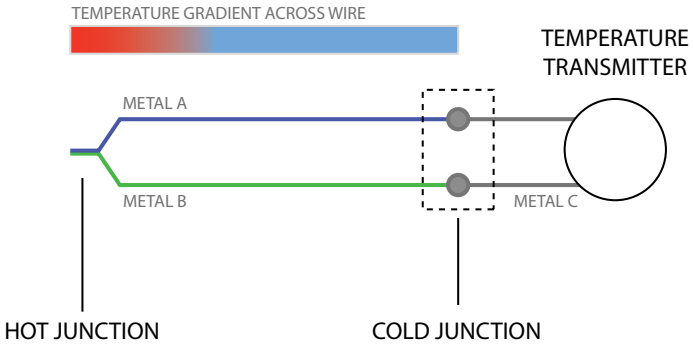
# Thermocouples

## Basic Concepts

### Principle

Thermocouples take advantage of the Thermoelectric Effect (or Seebeck Effect) to read temperature.

When the temperature varies across a single piece of metal, it generates a small current that is reflects the amount of temperature difference between the hot and cold ends of the metal.




The amount of current varies from metal to metal.

When you make a circut out of two disimilar metals - such as chromel and alumel, the two alloys used in Type K thermocouples - the difference in the voltage is an excellent measure of the temperature difference between the 'hot junction' (where the two metals meet) and the 'cold junction' (the end of the wire).

You then perform 'cold junction compensation' - using a resistive temperature sensor that is built into your converter, you can accurately calculate the temperature at the hot junction.

### Advantages

- Large temperature range
- Less expensive for the sensor
- Immune to vibration and resistant to damage
- Fast response
- Easy construction

### Disadvantages

- Less accurate than RTDs
- Converters tend to be more expensive
- Can not be extended with regular electrical cable

### Styles

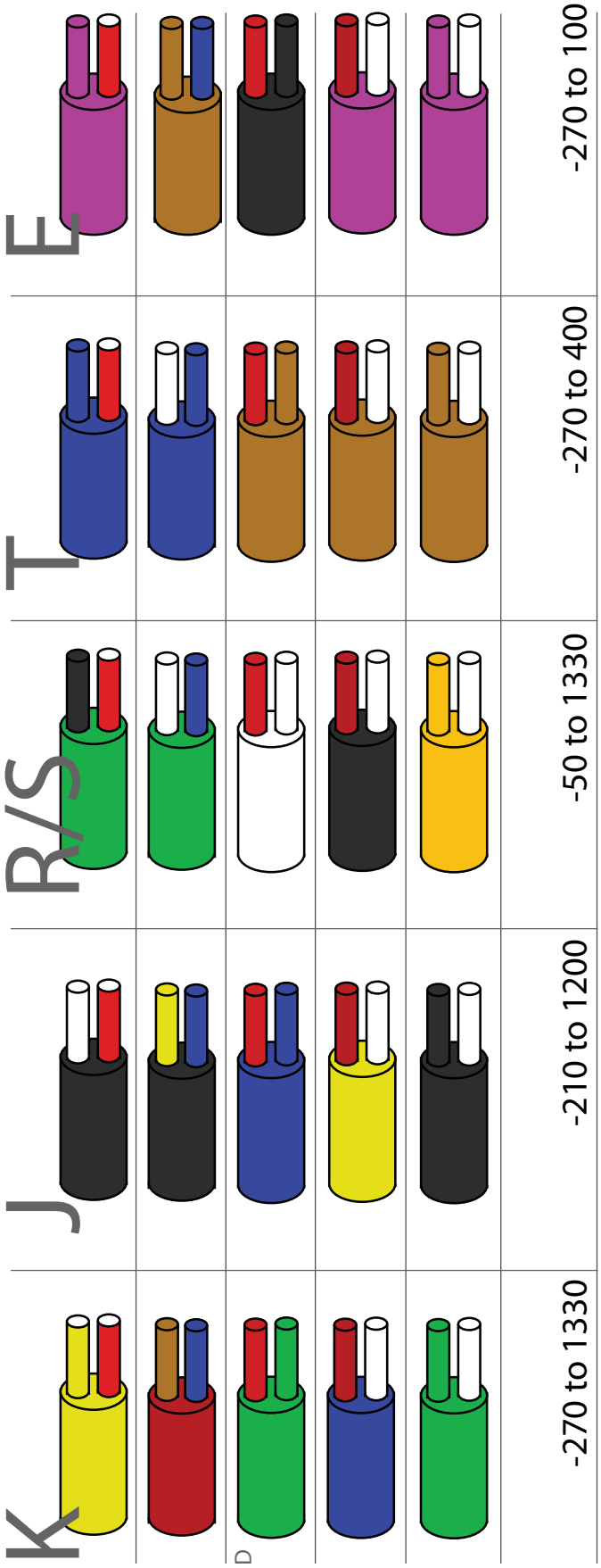
There are a wide variety of thermocouple types, many of which are used for extreme applications. Each is given a letter and colour code.

While the letter codes are consistent across the globe, the colour standards used do tend to vary from place to place. Australia has chosen to use the American ANSI standard, but in imported machinery you may find the Japenese or German colour systems being used as well.

The codes, ranges and construction materials are shown on the following page.

# Thermocouple Types

The Types of Thermocouple




## Considerations

Take special note of the black screen with red and white wires inside. This is a particularly difficult sensor because it could be...

- An ANSI Type J sensor
- A JIS Type R sensor
- or a 2-Wire RTD

While the type J is the most likely option if you are in Australia or the US, in some situations you may have to check by hooking the sensor up to a multimeter.

## Extending

RTDs can be extended using regular electrical cable, but thermocouples can not, as by changing the metal you are potentially creating an extra cold junction in your cabling.

Instead, you can purchase thermocouple extension cable, which in some cases is just regular thermocouple wire (as in type K, which is inexpensive) or is a less expensive cable with very similar thermal response (as in type R, as normal R cable is quite expensive).

## Trivia

Thanks to the law of conservation of energy, there is an opposite of the Thermoelectric Effect.

Thermocouples create a current thanks to a temperature difference. The Peltier effect allows you to create a temperature difference by inducing a current.

The Peltier effect isn't particularly efficient, which is why it is used in small sized food coolers and heaters, computer cooling and many other small-scale applications where fitting compressors and heat-exchangers would be difficult.

# Construction

## Building a Contact Temperature Sensor

### Designing a Sensor

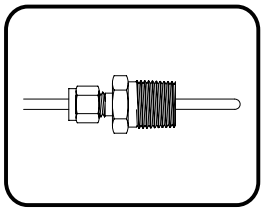
Many people think they can simply order an off-the-shelf 'RTD' and have it suit their requirements. In almost all cases, this is incorrect. While there are some common designs, the vast majority of temperature sensors are custom made to suit specific applications.

We can only offer a rough guide to what is possible - there are still countless options that we won't cover here.

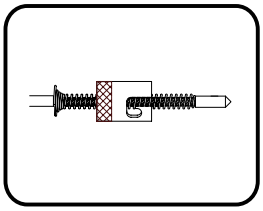
However, each sensor is made up of three or more sections.

### The Tip

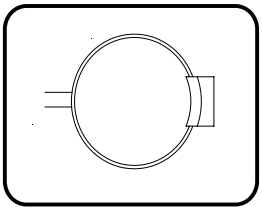
The tip of the sensor is the part that houses your junction or RTD bulb and is subjected to the most extreme conditions. You also need to consider how your sensor will actually be attached to the item you want to monitor.



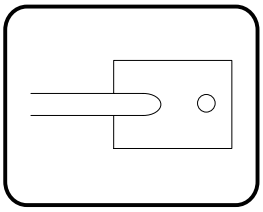
A stainless tube and sliding compression fitting to fit this sensor into a tapping point



A bayonet fitting allows you to connect and disconnect quickly and easily



A pipe-mounted sensor clamps straight onto your pipework



A surface sensor can be attached with adhesives

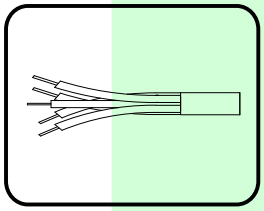
### The Middle

The middle of your sensor can be made up of any number of lengths of tube, wire, cable or conduit. You can include bulkhead fittings to allow you to pass through walls, brackets to clamp onto surfaces or different grades of protection that give you heat and impact resistance.

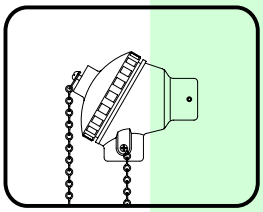
When it comes to cables, PVC is extremely inexpensive, PFA gives your sensor resistance to agressive chemicals, fiberglass braid can tolerate high temperatures and stainless steel armor gives you extremely high levels of mechanical protection. There are also many other materials and wire types you can use for different applications.

### The End

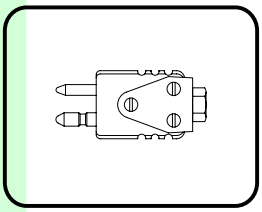
There are a number of options for how your sensor ends and plugs into your transmitters or other devices.



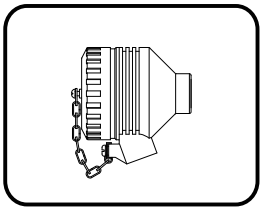
Bare or lugged wires allow you to connect to your converter directly



A terminal head houses either screw terminals or a small head-mounted transmitter



Plugs allow you to easily connect devices in and out



Ex D heads allow sensors to be installed in hazardous locations