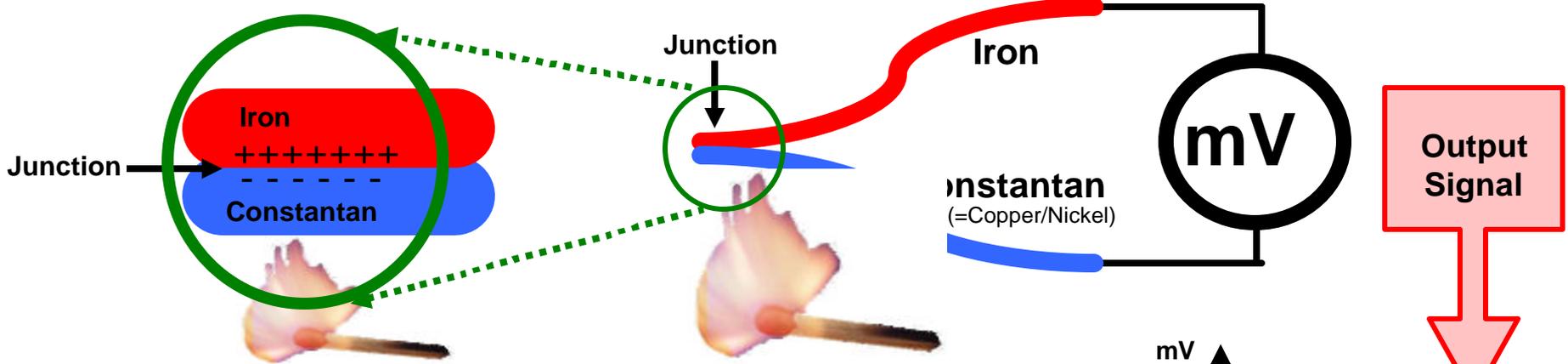


# 1) Thermo couple sensor Fundamental operation.



• In 1821 Mr. Seebeck found that if you connected 2 wires of different metals, a small Voltage would be generated, when this connection (junction) is heated.

For example if we put a wire of **Iron** and a wire of **Constantan** together, than we will get the following result:



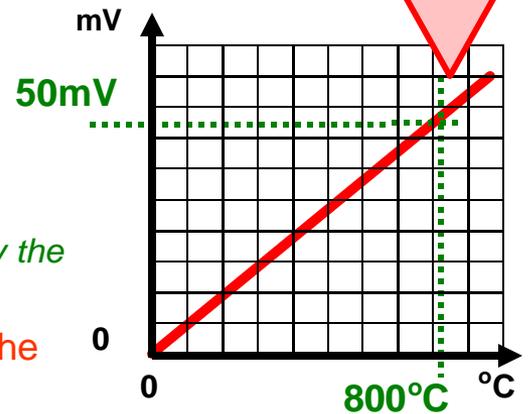
If we heat up the junction of the 2 metals: the Electrical activity will be DIFFERENT, because the 2 metals are DIFERENT !

**A closer look:** The atomic structure of the 2 metals is not the same! Therefore also the activity of the electrons in the atoms of the materials (*caused by the heating*) will be different. This causes a (small) Output Voltage between the wires!.

It was also discovered that the Output Voltage depends on the Temperature, the higher the Temperature, also the higher the Voltage will be..

With Iron/Constantan the Output Voltage will be around 50mV at 800°C

This forms the whole basis of the Thermocouple !



The output is almost an ideal straight line! If we know the mV value, we also know the process Temperature. Ideal basis for a Temperature sensor !

# 1) Thermo couple sensor In practical use.



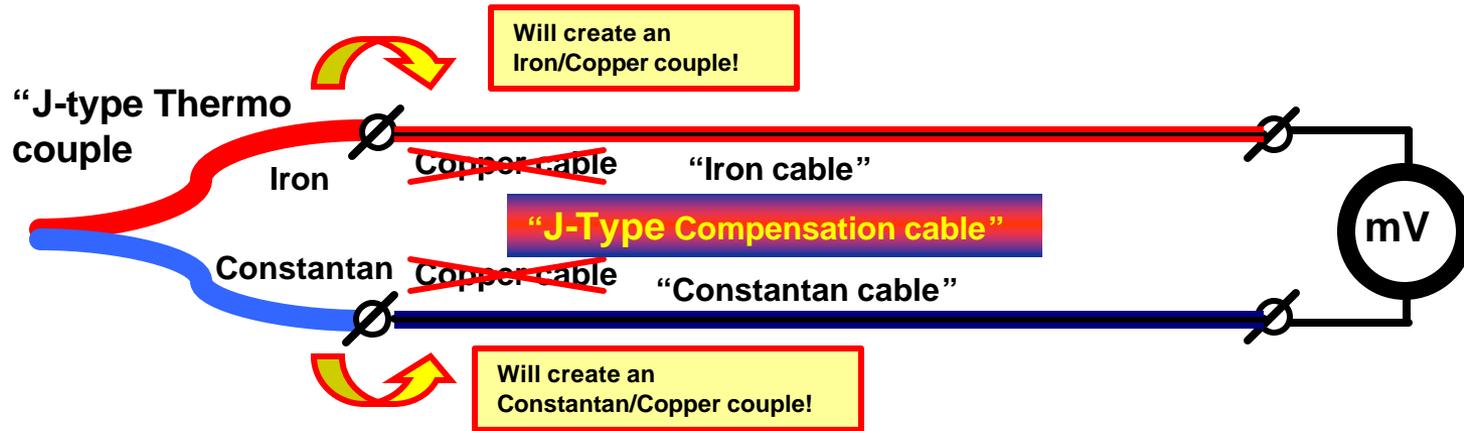
As we have just seen on the page before: It is not difficult at all to make a Thermo Couple!  
The Thermocouple we just discussed is used A LOT and is called the “J couple”.



**BUT:** There are two important points to know & understand about the actual use of Thermo couples, in PRACTISE!! *Let's have a closer look...*

When we connect the Thermo couple, we already get the “first problem”:

If we connect the Thermo couple to copper wires, than we will create an error as this connection!!!



The connection of Iron to Copper and also of Constantan to Copper will create two new couples, which would lead to a large measuring error! Therefore we have to use Iron and Constantan also as “extension cables”.

As an “Iron/Constantan extension cables” would be too expensive, we use two extension wires with the same Thermal response as Iron/Constantan. This connection cable is called: “Compensation cable”!

For this reason we can not connect Thermo couples with Copper cable to the TC, but have to use “compensation cable” using the right materials, similar to the Thermo couple that we use!

# 1) Thermo couple sensor In practical use.



That solves the problem of the connection of the Thermo couple.

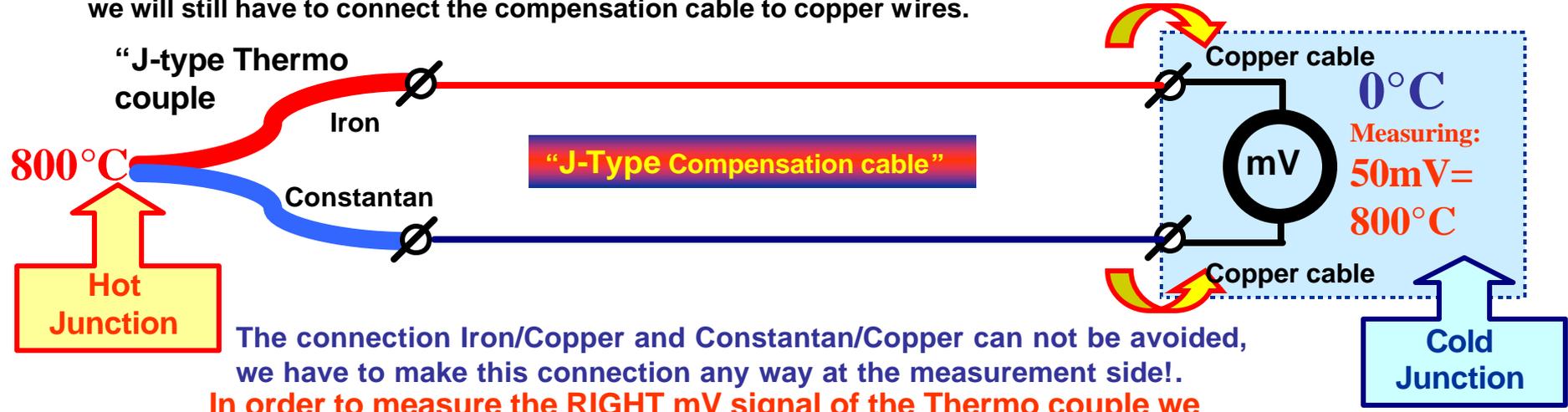
By using Compensation cable, we can avoid the error on the connection of the couple.



**BUT:** On the “measuring point” (mV meter or TC) we will have the SAME problem!!

**We will still get a connection to the Copper wires of the measuring device! (inside)**

At the output side of the cable, where we will measure the the output voltage, we will still have to connect the compensation cable to copper wires.



The connection Iron/Copper and Constantan/Copper can not be avoided, we have to make this connection any way at the measurement side!  
**In order to measure the RIGHT mV signal of the Thermo couple we have to keep the measurement side at a temperature of (exactly) 0°C!**

The temperature (=mV values) of Thermo couples are specified with the measurement side kept at a stable Temperature of 0°C. **This side is called the: “Cold Junction”.**

**The side of the Thermo couple is called the: “Hot Junction”.**

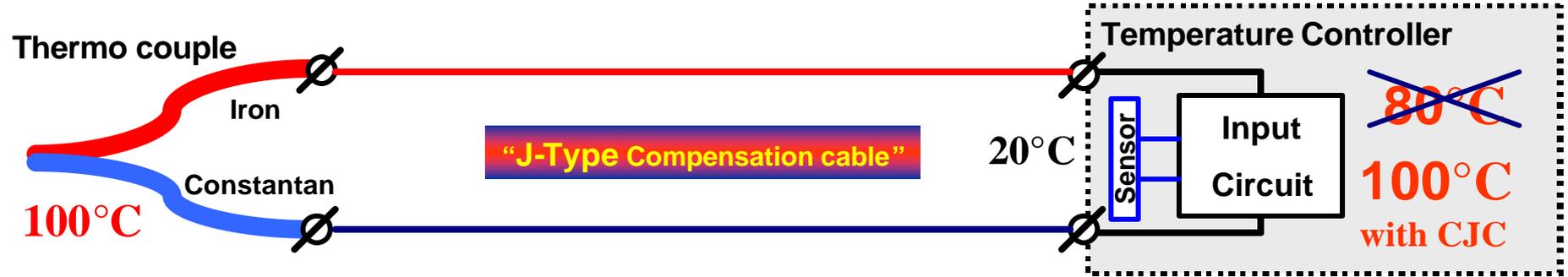
**This is how the whole Thermocouple operates and how we can measure the Temperature correctly !**

# 1) Thermo couple sensor Connection to the TC.

 In practical applications it would be VERY HARD to keep the cold junction exactly at 0°C!  
This would mean that we have to keep the Input of the Temperature Controller exactly at 0°C!

Lets have a look at the actual application:

If we measure 100°C and the temperature of the TC is 20°C, we make the following error:



The Thermo couple measures 100°C, but as the TC connection is 20°C higher than 0°C, the error will be 20°C. This will result in a measured + displayed value of 80°C on the TC!

This would be IMPOSSIBLE to work with in practice, as we can not control the cabinet temperature!

 To solve this problem all TC's with Thermo couple input have a Temperature sensor build in the TC, that accurately measures the temperature of the terminal connection!  
With this measurement we compensate the Temperature error of the cold junction!  
Therefore this function is called the "Cold Junction Compensation" (=CJC).

The error of 20°C is compensated in the input circuit and the TC will indicate exactly the measured 100°C.

Thanks to the Cold Junction Compensation we do not have to worry about the Temperature at the cold junction!  
All OMRON controllers can fully compensate the error at Cold Junction from -10°C to + 55°C !

# 1) Thermo couple sensor Connection to the TC.

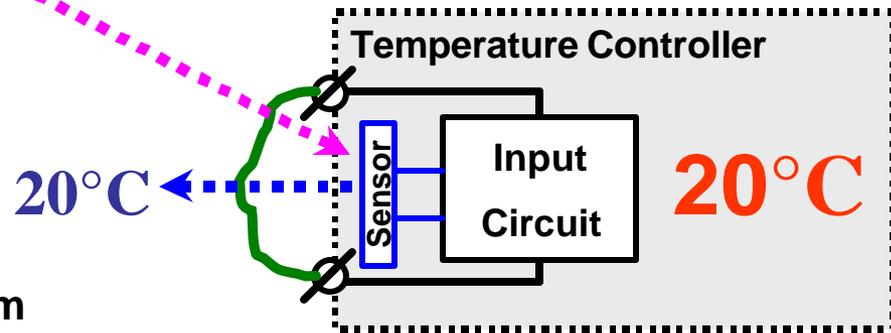


**Additional note for Thermo Couple input.  
For practical use.**

As explained: Because of the Cold Junction Compensation the Temperature Controller measures the actual Temperature on the input connections.

If we “short-circuit” the sensor input of the TC, than we will apply an input signal of 0mV !

As a result:  
The CJC sensor measures the room temperature (for example 20°C) and this value will be displayed on the TC.



**Because of the CJC the Controller will indicate the ambient Temperature on the display, if the input is short circuited !**

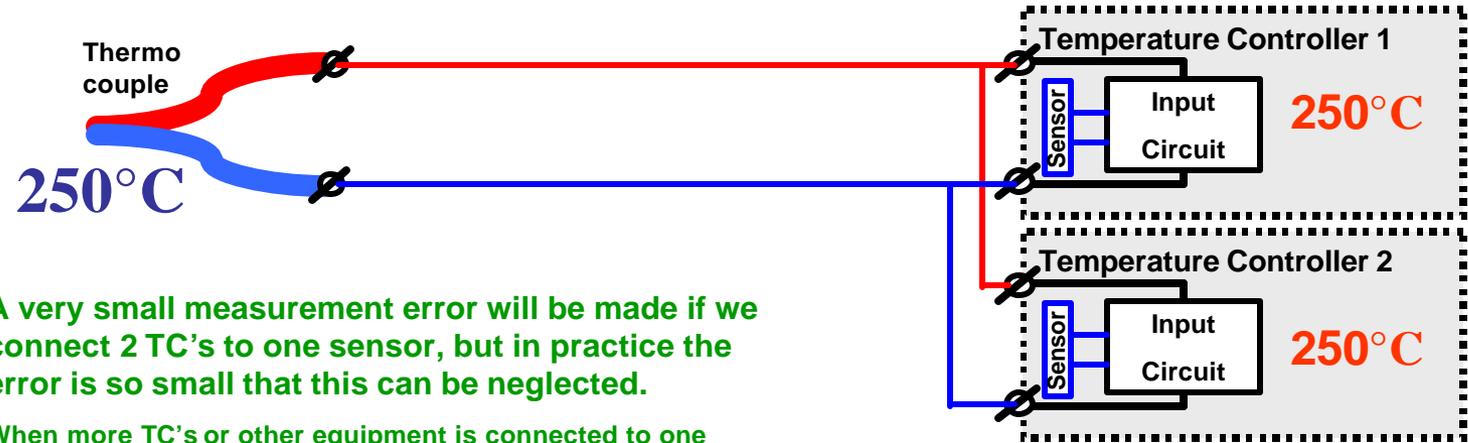
# 1) Thermo couple sensor Connection to the TC.



**Additional note for Thermo Couple input.  
For practical use.**

**A Thermocouple has a very low impedance, almost 0ohm.  
As the TC input has a high impedance, we can connect 2 (or more) TC's to a Thermocouple.**

**In case we need the measurement signal to go to two TC's,  
than we can connect the TC's in parallel to the same sensor:**



**A very small measurement error will be made if we connect 2 TC's to one sensor, but in practice the error is so small that this can be neglected.  
When more TC's or other equipment is connected to one Sensor the error will become larger.**

**TWO TC's can be connected to ONE Sensor, if needed.**

# Thermo couples (fundamental operation); conclusion:

That was a “rather detailed” explanation, *important to remember are:*

1. A Thermo couple is made by using two different metals combined together.(Usually welded together)
2. Thermo couples give a (small) mV signal, when they are heated. The mV signal depends on the Temperature.
3. The sensor side is called: the “Hot junction”.
4. The Thermo couple needs to be connected with extension cable, to prevent a (large!) measurement error!  
(Note: Pay also attention to the right polarity of the extension wires!)
5. The measurement side (TC) is called: the “Cold Junction”
6. The TC needs to have Cold Junction Compensation to correct the measurement error at the Cold Junction.
7. If the Sensor input is short-circuited the TC will indicate the room temperature.
8. Two TC’s can be connected to one sensor, if needed.

**In practice many mistakes are made with Thermo Couples !**

**That’s why we handled it in much detail!**

