# Calibration of Watlow Controllers

Occasionally questions come up with regard to calibration of Watlow controllers.   This paper will attempt to address some of the more common questions on this subject.

**Verification of controller calibration.**
Many people want to jump in right away and begin performing a calibration procedure before verification.  Before you would attempt to calibrate a Watlow controller, verify that the controller is in need of calibration.  If you verify that readings of the controller first, you may not have to go through the more involved process of changing the calibration settings. In this document is a general procedure that shows the process to verify the calibration of the controller.

**Are you performing calibration of the controller or the whole system of which the controller is a part?**
Sometimes people confuse the controller's calibration with calibration of the system, which contains the controller. A controller calibration would of course start with verification.  Provide the controller a known, calibrated input from a calibrator, and verify that the controller's indicated reading is within specifications.

By contrast, performing a system calibration involves using a separate calibrated temperature sensor and indicator to validate the temperature reading indicated by the controller using the system's sensor.  The designer of the system set the accuracy specifications for the system, and the exact method to test that accuracy.  If the system is outside of the accuracy specification, you could use the controller's calibration offset parameter to offset the reading indicated by the controller.

It may not be possible to readily perform this sort of comparison for system calibration.  For instance, the systems temperature sensor may be embedded within a heater or a block of some material such as steel.   In a situation like this, you may be only able to sense the outer surface temperature of the block, so there is likely to be a difference between the reading indicated by the controller and the reading indicated by the calibrated source.  In some cases you may want to offset the controller's reading, allowing the controller to indicate a temperature that may better reflect the system temperature rather that the internal block or heater temperature.  Again, the designer of the system set the exact test method and accuracy specification.

**Does the controller come from Watlow calibrated?**
Yes, the controller comes calibrated from the factory.  It is calibrated to a level of precision that will meet the needs of the majority of customers.  For most customers their controller will not require re-calibration for the lifetime of the product.

**How often do I need to calibrate the controller?**
Calibrate the controller as often as you find the calibration is out of specification. If you are verifying calibration first (see "Verification of calibration"), the answer to this question becomes self-evident.  Perhaps the question you mean to ask is "How often do I need to verify calibration of the controller?"

**How often do I need to verify calibration of the controller?**
As was mentioned, a Watlow controller's calibration is very stable.  Stable enough such that the majority of users would not need to calibrate their controllers within the lifetime of the product.  In general for most instruments and equipment, you may want to monitor calibration by doing verification at a regular interval.  This would detect calibration drift as well as failures in your system that could result in degradation in your process.  Proceed by arbitrarily picking a time interval such as six months based on how critical the instrument is to the process.  Then based on the results of repeated verification at this time interval, increase the time interval if no drift was experienced or decrease the time interval if adjustment was necessary.

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**What if a mistake or problem occurred while calibrating the controller?**

If a mistake or problem occurred while calibrating a controller use the calibration restore parameter to recover the original factory calibration settings. Watlow's recent microprocessor based controllers allow the calibration restore. This is a useful feature in troubleshooting accuracy and calibration problems. After performing a calibration restore, the controller should be indicating readings that are at worst case (assuming you had an unusually excessive amount of calibration drift) a few degrees outside of the accuracy specification. If the reading is extremely far off or if the controller is indicating a sensor error, then there is a problem other than calibration. Possible issues are; the controller is not programmed correctly, the calibrator is not wired correctly, the calibrator is not operating properly, or perhaps the controller is defective.

**Types of Calibration equipment**

**Thermocouple simulation**

For thermocouple inputs you can use an instrument called a thermocouple simulator that allows you to input a temperature setting in degrees and it will output the equivalent mV signal representing that temperature. Simulators are capable of producing signals for several different thermocouple types.

**RTD simulation**

There exist two common methods for simulating RTD resistances for various temperatures. The first is to use what is commonly referred to as a decade box (pictured above to the left). A decade box contains various size resistors that are connected together through rotary control switches on the front of the box to allow the user to "dial in" the desired resistance value. With a decade box, use a temperature to resistance lookup table to determine the resistance for the RTD.

The second method is to use an electronic RTD simulator (pictured above to the right) that will allow entry of a temperature through a keypad and the simulator will simulate the equivalent resistance for the specified RTD. Most simulators are programmable to simulate several different types of RTDs.

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## Current and Voltage simulation

Current and/or voltage simulation of process signals is performed with a simulator that allows entry of the desired current/voltage signal. Simulators are designed for both voltage and current simulation  Although any power supply that presents the appropriate voltages could be used for voltage calibration, only a source designed specifically for process signal calibration will allow for suitable adjustment and accuracy to perform calibration.

## Multi-Function Calibrators

Many simulators on the market sold for calibration purposes can simulate all of the above signals mentioned.  These units are handy if you have several different types of signals to simulate for various pieces of equipment that need to calibration.

## Calculating specified accuracy

For most controllers, the degree of accuracy depends upon the type of sensor utilized. Most Watlow controller's accuracy is stated as percent of span.  The accuracy statements can be found in the specification section of the user's manual.

For instance: a controller accuracy is stated as "± 0.1 % of span, ± 1°C".

The accuracy is dependent on the type of sensor and stated span.  Assuming a type J thermocouple's range is 0 to 750°C:

| | |
|---|---|
| 750 – 0 = 750°C | The span is 750°C |
| 0.1% * 750 = 0.75 = 1°C | Round to the nearest whole degree to obtain the error due to span |
| 1° + 1°  = ± 2°C | Add ± 1°C which is the second part of the specification |
| ± 2°C | The total calibration error for this controller using type J t/c |

This value applies under standard conditions.  Standard conditions refer to ambient controller environment temperature at which the controller was originally calibrated, input voltage within rated specifications, and specified humidity range.  There are modifiers for going outside of standard conditions.  The controller's user manual will specify the details for standard conditions and their modifiers of accuracy.

**General Procedure of Verifying Calibration**

1.  Obtain the necessary equipment.  To verify calibration, you need to obtain a calibration instrument to simulate the input signal you are going to verify. Cabling to attach the calibrator to the controller is required.  For RTDs, Voltage, and Current signals, use copper wire to make the connection.  For thermocouples, use the appropriate type of thermocouple wire to perform the test.
2.  Simulate a temperature.  Enter the temperature to simulate into the calibrator.  Pick temperatures to simulate that are within your normal operating range.  Typically you would pick three temperatures to verify: a high, a low and mid range temperature value for the operating range.
3.  Verify that the temperature readings on the controller are within specification.  (See calculating accuracy above)  If the readings are within specification, no calibration will be necessary.  If readings are outside of specification, perform the calibration procedure for the controller.