ECTRON MODEL 1140 CALIBRATION NOTES

Overview

The Model 1140 instruction manual contains full alignment and calibration procedures. Alignment adjusts the internal settings of a Model 1140 as needed to make it as accurate as possible, and calibration involves taking readings to verify the accuracy. If the user has the necessary equipment as listed in the instruction manual, they can perform these procedures themselves.

These procedures require connections to the front-panel terminals using thermocouple alloy wires. The alignment procedure requires placing a Type T thermocouple in an ice bath and connecting the other end to the Model 1140. The calibration procedure requires Type E thermocouple wire to connect to the Model 1140's terminals, forming a junction to copper wires in an ice point.

Additional equipment includes a null meter and a ten-volt dc standard.

Alignment

Doing an alignment will not void the warranty. Ectron encourages users to perform an alignment of the instrument if they run into out-of-tolerance conditions. Electronic instruments generally become more stable over time, so it's likely an alignment will solve the problem.

There are two parts to the procedure: Voltage Alignment and Terminal Alignment. Both parts should be performed. It is possible to do each part separately, which is appropriate under some limited circumstances. For instance, if there was a problem with the calibrated thermocouple or ice bath, a technician can repeat just the Terminal Alignment if necessary.

If copper wires are attached to the Type T thermocouple, the copper ends should be shorted together during alignment.

Be sure to follow all on-screen instructions when performing an alignment, including pressing any key to continue at the end. If the unit is turned off before this is done, the new alignment data will not be saved.

Calibration

Ectron recommends periodic alignment and calibration of the Model 1140, at an interval determined by the needs of the customer versus the stated specifications of the manufacturer and eventually also the performance of the unit over time. Most customers use a calibration interval of either 6 months or 1 year.

Section II of the instruction manual lists the accuracy for each thermocouple type in various time periods, allowing selection of the calibration interval appropriate for the user's accuracy needs. For example, the specification states that within 30 days of calibration the error with a Type T thermocouple at 100°C

will be within 0.05°C; after 6 months 0.06°C; and after 1 year within 0.07°C.

The fact that most of the calibration tests are done using copper wires is mainly to avoid the added uncertainty of thermocouple wires, and also to make it easier. Given the nature of the Model 1140's construction, copper-wire tests prove out most sections of the internal circuitry and alloy tests do the rest, ensuring in-tolerance operation. This is just for calibration, and does not reflect on how the instrument should be used. We know most uses of the instrument will be using alloy wires, and is what the instrument was designed to do.

Test-accuracy ratio (TAR)

The alignment and calibration equipment listed in the Model 1140 instruction manual will ensure a test-accuracy ratio (TAR) of greater than 4:1 for all measurements. If the user substitutes other instruments, care should be taken to ensure a TAR of at least 4:1 for all measurements. For example, the Model 1140 has a dc accuracy spec of 0.0025% + 2 µV for six months. Therefore, a calibrator or meter with accuracy of 0.0006% would be the least one should use for calibration purposes.

A minimum TAR of 4:1 is highly recommended for all calibration measurements; and if it is unattainable, methods such as guard banding should be employed. Very simply, guard banding means reducing the allowable range of the spec for measurement purposes. For example, if Ectron's specification is ±332 µV, guard banding may require that any measurement over 200 µV be called unsatisfactory. This increases the probability that a bad unit is not called good, but at the sacrifice of a good unit being called bad.

Thermocouple wires

Because of wire manufacturing tolerances, thermocouples never produce exactly the voltage expected. Commercially available thermocouple wire is generally available in two grades: standard and special limits of error. The following table shows the limits of error for Types E and T thermocouple wire:

	Standard Limits of Error	Special Limits of Error
Type E	±1.7°C ±0.5%	±1.0°C ±0.4%
Type T	±1.0°C ±0.75%	±0.5°C ±0.4%

Thermocouple wire offset

Aligning and calibrating an Ectron 1140 requires that one end of the thermocouple wire be immersed in an ice point while the other end is connected to the Model 1140's front-panel terminals near room temperature. As can be seen from the above table, using off-the-shelf thermocouple wire can introduce significant errors, given the temperature difference between the Model 1140 terminals and the ice point. Therefore, to properly align and calibrate the Ectron 1140, it is necessary to use calibrated thermocouples to compensate for errors.

This error can vary depending on the temperature at which the thermocouple is used: a Type E wire may have an error of –0.08°C at 15°C, –0.12°C at 26°C, and –0.13°C at 35°C. Thus, the thermocouple must be calibrated at approximately the same temperature as it will be used. Experience has shown that a lab environment of 23°C results in a temperature of approximately 26°C at the Model 1140's terminals, so Ectron calibrates its thermocouples at 26°C.

The Model 1140 has a thermocouple offset that can be used to compensate for known errors in the thermocouple or plug. This offset can be set from the front panel or a remote interface. From the front panel, it is in the THERMOCOUPLE menu.

Thermocouple calibration

A detailed procedure for thermocouple calibration is given in Appendix B of the Model 1140's instruction manual. It involves immersing the cold junction in an ice bath and the hot junction in a stable bath set to approximately 26°C. The exact bath temperature is

measured by a platinum resistance thermometer (PRT) and compared to the voltage output of the thermocouple to determine the wire's offset.

The short-term offset specification of the Ectron 1140 for Type E is ±0.06°C, and for Type T is ±0.05°C. To preserve a TAR of 4:1 requires thermocouples with offset known to better than ±0.015°C and ±0.0125°C, for Types E and T, respectively.

Calibration kit

Ectron's calibration kit includes Types E and T calibrated thermocouples (accuracy to <1 µV), high-grade copper cable, and a shorting bar for use in alignment and calibration. A calibration test report is included for each thermocouple to document the offset at 26°C. The calibrated thermocouple wires supplied in the cal kit are ready to use; welded junctions do not have to be cut prior to use.

Calibration with other thermocouple types

Almost any thermocouple type could be used for calibrating the Model 1140, but using a thermocouple with a higher Seebeck coefficient results in higher output voltage and better signal-to-noise ratio for the measurements. That is the sole reason for choosing Type E. Other types can be used if the voltage tolerances are changed by the ratio of the Seebeck coefficients between the two types.

For example, in theory a Type K thermocouple could be used to calibrate an Ectron 1140, but the Seebeck coefficient for Type K thermocouple near 0°C is 39.5 µV/°C, while for Type E thermocouple it is 58.7 µV/°C.

The one-year specified accuracy for the Model 1140 is ±0.07°C for both Types E and K at 0°C. The limit of error is 4.11 µV when using Type E thermocouple, and 2.76 µV when using the Type K thermocouple. Using a 4:1 test accuracy ratio, this results in an uncertainty limit of 1.03 µV and 0.69 µV, respectively. This accuracy must be maintained for the combination of the meter and the calibrated thermocouple used.

In our experience, achieving this level of accuracy for the Type K calibrated thermocouple may be difficult.

Type T cannot be used for the Model 1140 calibration because one of its wires is copper, so no emf is generated between it and the connector terminal. This setup would not detect an out-of-tolerance temperature sensor in the positive terminal. In order to calibrate all the temperature sensors, a thermocouple must be used in which neither wire is copper.

Thermocouple wire recalibration

The calibration of the thermocouple wires used for Model 1140 alignment and calibration is a one-time calibration, provided the wires are not later abused in some way—that is, not subjected to temperatures over 200°C or damaged.

We realize that the ends of the calibrated thermocouple wires will eventually break even in normal use, and they will have to be cut back and stripped. Ectron recommends that a thermocouple wire be recalibrated if shortened by more than 3 inches from its length when last calibrated.

Connections

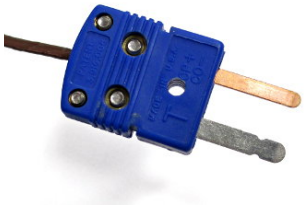
Temperature compensation at terminals

The temperature of each output terminal is independently measured in the Model 1140, and compensation is independently applied to cancel the emf's generated at each of the terminals.

During calibration, it is important that the technician switch settings in the Model 1140's menu from BINDING POST to THERMOCOUPLE CONNECTOR for the two thermocouple zero steps. In the menu system, it is found in the TERMINALS setting in the OUTPUT menu. This will ensure compensation of the proper temperatures.

Thermocouple connectors

Ectron has found that some types of thermocouple plugs can introduce errors which may result in an out-of-tolerance condition during calibration of the Model 1140.



When performing terminal alignment and calibration, Ectron technicians normally do not use a thermocouple connector as the commercially available connectors introduce too much error. Instead, the bare wires of the calibrated thermocouple are inserted into the thermocouple receptacle (observing proper polarity) when instructed to do so during the alignment. The wires should be inserted all the way into the holes (½″) so that the connections are made as close as possible to the temperature sensors.

Do not use bayonet type thermocouple adapters unless their error is known and factored in.

Reducing calibration error

Reduce air flow

Air flowing past the front panel of a Model 1140 can introduce offsets when using thermocouple alloys to make the connections to the instruments. These offsets are due to the transition from thermocouple alloys to copper at the instrument terminals, and the gradient produced in the vicinity of these connections due to the air flowing past.

The temperature of these junctions is measured and compensated for, but increased air flow can introduce small gradients that aren't compensated. The effect of air flow can be minimized by shielding the terminals from air sources with baffles, by placing foam over the terminals, or by performing the alignment and calibration procedures in an area of the lab less subject to air flow.

Ectron's calibration kit includes a terminal cover designed specifically for this purpose.

Increase settling time between steps

During the Model 1140 terminal alignment a delay of two minutes is built in to allow gradients to diminish, and during calibration the procedure recommends a one-minute stabilization period before taking the thermocouple alloy readings. However, these stabilization times may not always be adequate to get precise readings. Drafts from HVAC vents and doorways, and heat from other equipment or the technician's hands can sometimes cause fluctuations and lengthen stabilization times.

Given variations in lab conditions, Ectron's recommendation is to wait long enough for the readings to stabilize to the degree needed for the particular test. Typically, technicians at Ectron allow 6–10 minutes prior to pushing the button to start the two-minute countdown during alignment, and allow 5 minutes for stabilization during calibration.

Wire gauge

Ectron typically uses 24 AWG thermocouple wire; thicker wire may require longer to stabilize. In addition, Ectron has found that 20 AWG wire is too thick to slide easily into the mini thermocouple connector, and if forced it may produce erroneous readings or even damage the connector.

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