

51 K/J THERMOMETER

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English

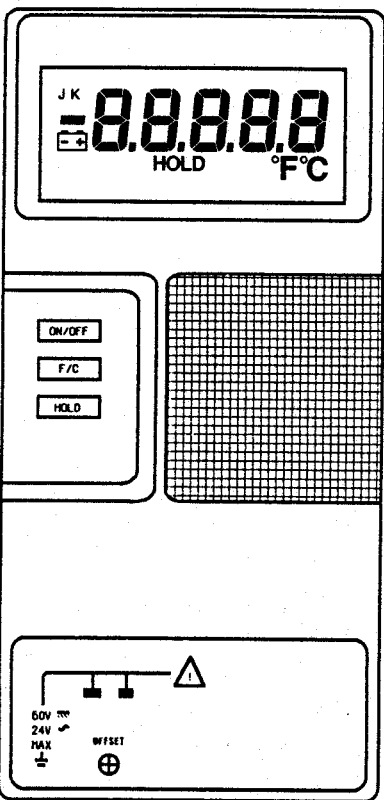


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INTRODUCTION

This instrument is a microprocessor-based, digital thermometer designed to use an external K-type or J-type thermocouple as a temperature sensor. Temperature indication follows National Bureau of Standards and IEC 584 temperature/voltage curves for K-type and J-type thermocouples. A K-type thermocouple is supplied with the thermometer.

It is recommended that you read the safety and operating instructions before using the thermometer.

NOTE

A quick operating guide is located on page 5 to get you started using the thermometer quickly.

SAFETY INFORMATION

WARNING

TO AVOID ELECTRICAL SHOCK, DO NOT USE THIS INSTRUMENT WHEN VOLTAGES AT THE MEASUREMENT SURFACE EXCEED 24V AC OR 60V DC.

WARNING

TO AVOID DAMAGE OR BURNS, DO NOT MAKE TEMPERATURE MEASUREMENTS IN MICROWAVE OVENS.









CAUTION


Repeated sharp flexing can break the thermocouple lead. To prolong lead life, avoid sharp bends in the lead, especially near the connector.

This instrument has been designed and tested according to IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This manual contains information and warnings that must be followed to ensure safe operation and to protect the thermometer.

This instrument complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this instrument may not cause harmful interference, and (2) this instrument must accept any interference received, including interference that may cause undesired operation.

Some common international symbols used in this manual are shown below.

	AC - ALTERNATING CURRENT		DANGEROUS VOLTAGE
	DC - DIRECT CURRENT		EARTH GROUND
	EITHER AC OR DC CURRENT		SEE EXPLANATION IN MANUAL
	FUSE		DOUBLE INSULATION FOR PROTECTION AGAINST ELECTRIC SHOCK

The  symbol on the instrument indicates that the operator must refer to an explanation in this manual.

In this manual "WARNING" is reserved for conditions and actions that pose hazard(s) to the user; "CAUTION," is reserved for conditions and actions that may damage your thermometer.

Do not use this thermometer if the thermometer looks damaged, or if you suspect that the thermometer is not operating properly.

OPERATIONAL LIMITATIONS

The thermometer is designed to operate within the following conditions:

- **THERMOCOUPLE MEASUREMENT RANGE:**

K-type thermocouple: -200°C to 1370°C (-328°F to 2498°F) (See Appendix A.)

J-type thermocouple: -200°C to 760°C (-328°F to 1400°F)

- **INSTRUMENT ENVIRONMENT:**

Temperature: 0°C to 50°C (32°F to 122°F)

Humidity: 0% to 90% (0°C to 35°C) (32°F to 95°F)
0% to 70% (35°C to 50°C) (95°F to 122°F)

The thermometer displays an error indication (Figure 1) if the thermometer itself is subjected to temperatures outside the instrument environment range listed above. However, if the thermometer is initially at an ambient temperature of 20°C (68°F), it will typically provide accurate readings for 5 minutes down to an ambient temperature of -26°C (-15°F).

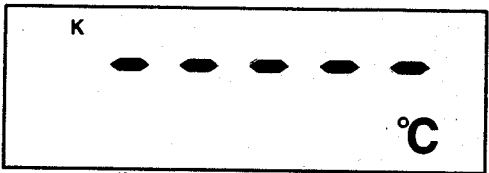


Figure 1. Error Indication


The thermometer is designed to provide accurate readings even when it is subjected to rapid ambient temperature changes (for example, when carried from a cold vehicle to a warm building). For an ambient temperature step change of up to 35°C (63°F), readings are within 1 degree of specified accuracy immediately, and within specified accuracy within 10 minutes.

Thermocouple limitations are discussed later in this manual. If you are using another manufacturer's thermocouple, consult the manufacturer's specifications for that thermocouple.

FEATURES

Display

Each item in the display is described below and keyed by number to the illustration inside the back cover of this manual.

- 1 **NUMERIC DISPLAY**
The numeric display indicates the temperature of the thermocouple connected to the input.
- 2 **°F°C TEMPERATURE SCALE ANNUNCIATOR**
Either the °C or °F symbol is displayed, indicating whether temperature readings are displayed in degrees Celsius or degrees Fahrenheit.
- 3 **HOLD HOLD MODE ANNUNCIATOR**
This symbol indicates that the thermometer is in HOLD mode. (See "HOLD Mode," later in this manual.)
- 4  **LOW BATTERY ANNUNCIATOR**
This symbol appears when approximately 50 hours of battery life remain. For proper operation, replace the battery as soon as possible. (Refer to "Battery Replacement," later in this manual.)
- 5 **JK THERMOCOUPLE TYPE ANNUNCIATOR**
This symbol indicates which type of thermocouple (K or J) the thermometer is set up to use.

NOTE

For readings to be correct, be sure that the displayed thermocouple type matches the type of thermocouple you are using.

Controls

The thermometer's controls are briefly described below and keyed by number to the illustration inside the back cover of this manual.

- 6 **ON/OFF**
The ON/OFF key turns the thermometer on or off.
- 7 **F/C**
The F/C key switches between the Celsius (°C) and Fahrenheit (°F) scales on the display.
- 8 **HOLD**
Pressing the HOLD key selects HOLD mode. (See "HOLD Mode," later in this manual.) If pressed

during power-up, the HOLD key changes the selection of thermocouple type.

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OFFSET

The OFFSET control allows you to optimize measurement accuracy for a particular thermocouple at a particular temperature. (**IMPORTANT:** Before adjusting this control, read "Offset Adjustment," later in this manual.)

Open Thermocouple Indication/Error Indication

The error indication (Figure 1, page 3) is displayed if any of the following conditions occur:

1. If the thermocouple is unplugged, broken or open-circuited.
2. If the thermometer itself is subjected to temperatures outside its specified environmental range.

While the error indication is displayed, the annunciators still indicate which features have been selected (thermocouple type, temperature scale, etc.).

QUICK OPERATING GUIDE

The following procedure is intended to familiarize you quickly with the thermometer's operation. Start with the thermocouple disconnected from the thermometer.

1. Press the ON/OFF key. The self-test display appears briefly (see Figure 2). The display then shows the error indication (Figure 1), indicating that no thermocouple is plugged in. If the thermometer should fail the self-test, the self-test display will flash several times.

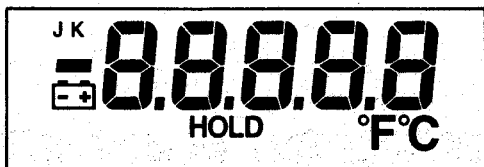


Figure 2. Self-Test Display

At power-up, the thermometer is set up to measure temperatures with K-type thermocouples. (To set up the thermometer for J-type thermocouples, see "Selecting the Thermocouple Type.") The thermometer uses the same temperature scale ($^{\circ}\text{C}$ or $^{\circ}\text{F}$) that was in use when the thermometer was last turned off.

2. Insert a K-type thermocouple into the input connector. The thermometer will display the temperature of the thermocouple (see Figure 3).

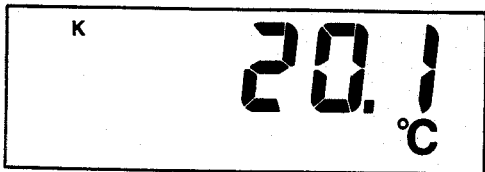


Figure 3. Example Temperature Reading

3. Press the HOLD key to stop all temperature measurements. The last reading is still displayed. Press the HOLD key again to continue measurements.

OPERATING INSTRUCTIONS

The following paragraphs describe the thermometer's operation in detail.

Power-Up

When the thermometer is turned ON, all display segments appear while the thermometer performs a brief self-test (see Figure 2). If the thermometer should fail the self-test, the display will flash several times, and the thermometer will attempt to resume normal operation. If this occurs, contact the nearest Service Center.

After about 3 seconds, the thermometer displays the first temperature reading. If no thermocouple is plugged into the input, the thermometer displays the error indication (Figure 1).

Connecting the Thermocouple

The thermometer can be used with either K-type or J-type thermocouples. For readings to be correct, the thermometer

must be set for the type of thermocouple you are using. The setting is indicated on the display by a K or a J.

The thermometer is set at the factory to default to K-type thermocouples. This is the correct setting for the thermocouple included with the thermometer.

To set the thermometer for J-type thermocouples, see "Selecting the Thermocouple Type."

Temperature Measurement

The thermometer displays the temperature of the thermocouple that is connected to the input. If the thermocouple is unplugged or open-circuited, the thermometer displays the error indication.

Selecting the Temperature Scale

Readings are displayed in either degrees Celsius ($^{\circ}\text{C}$) or degrees Fahrenheit ($^{\circ}\text{F}$). When the thermometer is turned on, it is set to the temperature scale that was in use when the thermometer was last turned off. To change the temperature scale, press the F/C key.

HOLD Mode

Pressing the HOLD key selects HOLD mode. When HOLD mode is selected, the thermometer stops taking temperature measurements and retains the last reading on the display. Pressing the HOLD key again cancels HOLD mode, causing the thermometer to resume taking measurements.

While HOLD mode is selected, the F/C key can still be used.

Selecting the Thermocouple Type

The thermometer accepts either K-type or J-type thermocouples. The thermometer is set at the factory to default to K-type thermocouples at power-up.

To select the alternate type of thermocouple, first turn the thermometer OFF. Then, while keeping the HOLD key pressed, press the ON/OFF key. After 2 to 3 seconds, release the HOLD key. The thermocouple type annunciator will indicate that the alternate thermocouple type has been selected.

NOTE

For readings to be correct, be sure that the displayed thermocouple type matches the type of thermocouple you are using.

To change the default thermocouple type, the case must be opened as described in the Battery Replacement procedure, later in this manual. Jumper W1 (see Figure 4) determines the default selection. When W1 is installed, the default selection is set for K-type thermocouples. When W1 is cut, the default selection is set for J-type thermocouples. REFER TO A QUALIFIED TECHNICIAN TO HAVE THIS MODIFICATION PERFORMED. K-type thermocouples can still be selected by pressing the HOLD key at powerup.

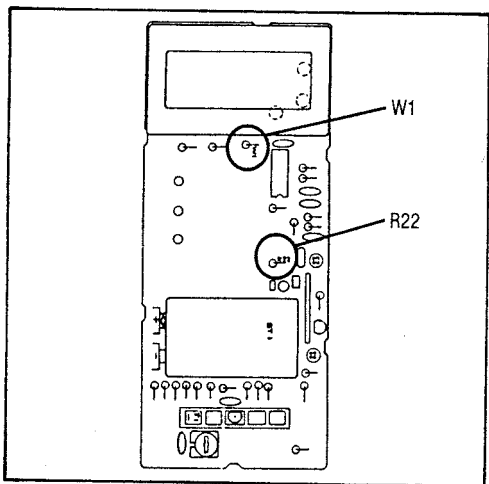


Figure 4. Selecting the Resolution and Default Thermocouple Type

Selecting the Display Resolution

The thermometer allows two choices of display resolution:

High resolution: 0.1°C (0.2°F)

Low resolution: 1.0°C (1.0°F)

The thermometer is set at the factory for high resolution. To change the resolution, the case must be opened as described in the Battery Replacement procedure. Jumper R22 (see Figure 4) determines the resolution selection. When R22 is installed, high resolution is selected. When R22 is cut, low resolution is selected. REFER TO A QUALIFIED TECHNICIAN TO HAVE THIS MODIFICATION PERFORMED.

OFFSET ADJUSTMENT

The OFFSET control is set at the factory to allow for the variations found in standard thermocouples. By adjusting the OFFSET control, you can optimize measurement accuracy for a particular thermocouple at a particular temperature.

NOTE

To return the OFFSET control to its factory setting, refer to thermocouple input calibration procedure located on page 3-7 in the 51/52 Service Manual (P/N 768234). The OFFSET control should be adjusted only when planning to make long-term measurements at a single temperature using a particular thermocouple. The OFFSET control does not need to be adjusted to obtain the accuracy specified for the thermometer and thermocouple.

The OFFSET control is adjusted using a small screwdriver. TO ENGAGE THE CONTROL, PRESS DOWNWARD GENTLY AS YOU TURN THE SCREWDRIVER. When the limit of its rotation is reached, the OFFSET control slips with a ratchet-like feeling. The OFFSET control has a range of approximately $\pm 3^{\circ}\text{C}$ ($\pm 5^{\circ}\text{F}$).

Adjusting the OFFSET Control

To adjust the OFFSET control for optimum accuracy with a particular thermocouple at a particular temperature, perform the following procedure:

1. Connect the thermocouple to the thermometer's input connector and turn the thermometer ON.
2. Place the thermocouple in a known, stable temperature environment at or near the temperature you wish to measure, and allow the readings to stabilize.
3. Slowly adjust the OFFSET control so that the thermometer reading matches the temperature of the known environment. Leave sufficient time between adjustments to allow for measurement lag.
4. The calibration of the thermometer-thermocouple combination is now optimized for measurements near the temperature measured in step 2.

Resetting the OFFSET Control

To return the OFFSET control close to its factory setting without having to recalibrate the thermometer, perform the following procedure:

1. Connect a thermocouple that is in good working order to the thermometer's input connector.
2. Place the thermocouple in an ice-water bath and allow the readings to stabilize.

NOTE

To create an ice-water bath, add crushed ice to a styrofoam cup (or other insulated container), fill the cup with water to the top of the ice, and stir during measurement.

3. Slowly adjust the OFFSET control until the thermometer reads 0°C (32°F).

INTERNAL CALIBRATION

The thermometer should be calibrated once a year to ensure its accuracy is within specifications. To calibrate the thermometer, refer to the Service Center nearest you or to the Service Manual listed on page 24.

MEASUREMENT TECHNIQUES

The following paragraphs present several suggestions for getting the best accuracy from your temperature measurements.

Choosing a Thermocouple Probe

The thermocouple shipped with your thermometer is a bead thermocouple, which is designed for general-purpose use. For optimum accuracy, use the style of probe that is appropriate for each type of application. Use an immersion probe for liquid or gel measurements, an air probe for air measurements, a surface probe for surface measurements, etc.

Thermocouple Connectors

Thermocouple connectors are made from the same materials as thermocouple wires. To avoid error, it is important to use a thermocouple connector whose materials matches the thermocouple you are using. The thermocouple included with the thermometer has the correct type of connector already installed.

When attaching a miniature thermocouple plug to a K-type or J-type thermocouple, ensure that the thermocouple connector type matches the thermocouple type. The correct connections are shown in Table 1.

Table 1. Thermocouple Connections

<p>K TYPE (Yellow connector body)</p>	<p>POSITIVE (+) LEAD: NON-magnetic Yellow insulation (if color coded) Chromium-nickel alloy (Chromel) Connects to narrow connector blade</p> <p>NEGATIVE (-) LEAD: Magnetic Red insulation (if color coded) Aluminum-nickel alloy (Alumel) Connects to wide connector blade</p>
<p>J TYPE (Black connector body)</p>	<p>POSITIVE (+) LEAD: Magnetic White insulation (if color coded) Iron Connects to narrow connector blade</p> <p>NEGATIVE (-) LEAD: NON-magnetic Red insulation (if color coded) Copper-nickel alloy (Constantan) Connects to wide connector blade</p>
<p>NOTE: These color codes are USA standards. Color codes may vary by country.</p>	

Reducing Thermal Error

In surface temperature measurements, error can result if there is a poor thermal connection between the thermocouple and the material being measured. Here are some suggestions for reducing thermal error:

- Ensure that there is a good connection between the thermocouple and the surface you are measuring. You can do this several ways:
 1. Clean the surface you are measuring.
 2. Use adequate mounting pressure.

3. Use a thermal conducting compound (such as silicone grease) between the thermocouple and the surface you are measuring. (Use thermal epoxy if you want a permanent connection.)
- When you are measuring above-ambient temperatures, adjust the connection of the thermocouple to the surface until you get the highest temperature reading. Use any of the suggestions given above to do so.
 - Similarly, when you are measuring below-ambient temperatures, adjust the connection of the thermocouple to the surface until you get the lowest temperature reading. Use any of the suggestions given above to do so.
 - When measuring near-ambient temperatures, take the reading when the thermometer's display is most stable.

Other Sources of Error

Excessive voltage potentials at the measurement surface can cause incorrect readings and/or instrument damage. Use caution when making temperature measurements in the presence of live circuits. Observe the maximum voltage limitations (24V ac or 60V dc).

Strong low-frequency and radio-frequency fields can also cause incorrect temperature readings.

THERMOCOUPLE LIMITATIONS

Thermocouple performance is subject to environmental and electrical limitations, as well as to the inherent accuracy limitations of the thermocouples themselves. The limitations for K-type and J-type thermocouples are summarized in Table 2. Appendix A lists the specifications for the thermocouple included with the thermometer.

OPERATOR MAINTENANCE

WARNING

**TO AVOID POSSIBLE ELECTRICAL SHOCK,
DISCONNECT THE THERMOCOUPLE CON-
NECTOR FROM THE THERMOMETER BE-
FORE REMOVING THE COVER.**

Battery Replacement

The thermometer is powered by a single 9V battery (NEDA 1604, 6F22, or 006P). Referring to Figure 5, use the following procedure to replace the battery:

Table 2. Thermocouple Characteristics

PARAMETER	J-TYPE THERMOCOUPLES
Temperature Range -328°F to 1400°F	-200°C to +760°C
Environmental Limitations	Alloy is brittle below 0°C. OK for reducing or oxidizing atmospheres or in vacuum. Not OK for sulfurous atmospheres above 500°C.
Color Codes	See Table 1.
Initial Tolerances	Standard: ±2.2°C or 0.75%* (±3.96°F or 0.75%*) Special: ±1.1°C or 0.38%* (±1.98°F or 0.38%*)
PARAMETER	K-TYPE THERMOCOUPLES
Temperature Range	-270°C to +1370°C -454°F to 2498°F
Environmental Limitations	OK for clean, oxidizing or inert gas atmospheres. Not OK for vacuum at high temperatures. Corrodes in low-temperature, oxygen-poor atmospheres.
Color Codes	See Table 1.
Initial Tolerances	Standard: ±2.2°C or 0.75%* (±3.96°F or 0.75%*) Special: ±1.1°C or 0.38%* (±1.98°F or 0.38%*)
* whichever is greater	

1. Remove the four case screws with a #2 Phillips screwdriver and separate the case halves by pulling them straight apart.

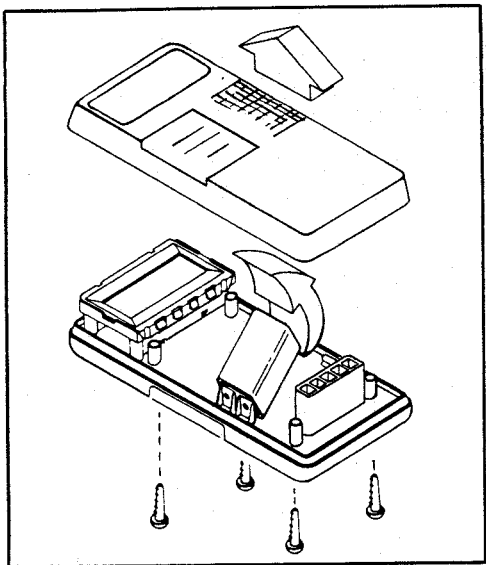


Figure 5. Battery Replacement

2. Disengage the battery from the battery contacts by prying the battery away from the clips.
3. Install a fresh battery by squeezing the battery against the battery contacts. Make sure that the battery is fully seated in the contacts.
4. Reassemble the case halves.
5. Install the four case screws with a #2 Phillips screw driver, taking care to tighten the screws only finger tight (6-7 in-lbs).

Proper Care of Thermocouples

To maintain a thermocouple in good condition, observe the following precautions.

- **AVOID EXCESS BENDING**

Bending changes the thermoelectric characteristics to some extent, especially where the wire is subject to high

thermal gradients. Bending can also break the wire. If it is necessary to bend the wire, give the bend a large radius. Be careful not to bend the wire sharply, especially where it exits the connector.

- **DON'T OVERHEAT THE THERMOCOUPLE**

Usually, the first thing to fail on a thermocouple assembly is its insulation, handle, or other supporting material. Almost always, the wire can withstand more heat than its insulation can. See the manufacturer's specifications for the maximum temperature of any thermocouple assembly.

The wire itself can lose its accuracy if it is allowed to operate for extended periods of time near the high limit of its specifications. This is due to annealing and contamination of the wire's composition.

- **AVOID CHEMICAL REACTIONS THAT CAN DAMAGE THE THERMOCOUPLE**

The presence of various gasses and fluids at particular temperatures can contaminate, etch, or chemically combine with the thermocouple wire. Such conditions can affect its accuracy. The manufacturer's publications will show what to watch out for.

Cleaning

Clean the thermometer with a damp cloth and a mild detergent. Do not use abrasives, solvents, or alcohol.

INSTRUMENT SPECIFICATIONS

Instrument specifications are shown in Table 3.

SERVICE CENTER REPAIR

If the thermometer fails, forward it, postage paid, to one of the Fluke Service Centers listed at the back of this manual. Include a description of the difficulty, and pack the instrument securely; Fluke shall assume NO responsibility for damage in transit.

IN WARRANTY: Instruments covered by the limited warranty will be promptly repaired or replaced, at Fluke's option, and returned, all at no charge. See the registration card for warranty terms.

OUT OF WARRANTY (USA AND CANADA): The instrument will be repaired and returned for a fixed fee. (Repairs needed because of abuse or accidental damage will be quoted.) Contact the nearest Service Center for current prices. Include a check, money order, or purchase order with the instrument.

OUT OF WARRANTY (OUTSIDE USA AND CANADA):
Service programs may vary by country. Contact the nearest
Service Center for information.

Table 3. Instrument Specifications

NBS CONFORMITY

The thermometer conforms to the temperature/voltage tables of the National Bureau of Standards and to the IEC 584 standards for K-type and J-type thermocouples.

ELECTRICAL

Measurement Range:

K-type thermocouple: -200°C to $+1370^{\circ}\text{C}$ (-328°F to $+2498^{\circ}\text{F}$)

J-type thermocouple: -200°C to $+760^{\circ}\text{C}$ (-328°F to $+1400^{\circ}\text{F}$)

NOTE

This specification applies only to the thermometer and may differ from the thermocouple range. To prevent damage to the thermocouple, check the specification before using. For the thermocouple supplied with this thermometer, see Appendix A.

Resolution:

High: 0.1°C or 0.2°F

Low: 1°C or 1°F

Accuracy:

For operating temperatures over the range of 18°C to 28°C (64°F to 82°F), for 1 year, not including thermocouple error (see "Thermocouple Limitations"):

K-type thermocouple: $\pm(0.1\%$ of reading $+ 0.7^{\circ}\text{C}$)
($\pm[0.1\%$ of reading $+ 1.3^{\circ}\text{F}]$)

J-type thermocouple: $\pm(0.1\%$ of reading $+ 0.8^{\circ}\text{C}$)
($\pm[0.1\%$ of reading $+ 1.4^{\circ}\text{F}]$)

Table 3. Instrument Specifications (cont)

Temperature Coefficient (for ambient temperatures from 0°C to 18°C and 28°C to 50°C [32°F to 64°F and 82°F to 122°F]):

For each °C (°F) ambient below 18°C (64°F) or above 28°C (82°F), add to the accuracy specifications:

0.01% of reading + 0.03°C
(0.01% of reading + 0.03°F)

Input Protection:

60V dc or 24V rms ac maximum input voltage on any combination of input pins.

Reading Rate: 1 second per reading

ENVIRONMENTAL

Ambient Operating Range:

0°C to 50°C (32°F to 122°F)

Will operate to -26°C (-15°F) for 5 minutes when taken from a 20°C (68°F) environment.

Storage Temperature:

-40°C to 60°C (-40°F to 140°F).

Humidity:

0% to 90% (0°C to 35°C) (32°F to 95°F)

0% to 70% (35°C to 50°C) (95°F to 122°F)

RF Fields: Exposure to an RF field interferes significantly with this instrument's capacity to accurately measure temperature with thermocouples. The interference is temporary and the instrument suffers no harm when exposed to an RF field of 3 V/m. Accurate

Table 3. Instrument Specifications (cont)

temperature measurement capability is completely restored when the instrument is removed from the RF field.

Common sources of RF fields are handheld walkie-talkies and cellular telephones. If such a source is suspected of interfering with this instrument, either turn off the transmitter or increase the separation between the transmitter and the instrument.

GENERAL

Weight: 280 gm (10 oz)

External Dimensions: 2.84 cm. x 7.49 cm. x 16.64 cm.
(1.2 in. x 2.95 in. x 6.55 in.)

Battery: Standard 9V battery (NEDA 1604, 6F22, or 006P)

Battery Life: 1200 hours. Low battery indicator appears when less than 50 hours of battery life remain.

Input Connector: Accepts standard miniature thermocouple connectors (flat blands spaced 7.9 mm or 0.312 inch, center to center).

Protection: Class III as defined in IEC 348, Safety Requirements for Electronic Apparatus.

Accessories:

80PK-1 K-Type Bead Thermocouple (included)

80PK-2A K-Type Immersion/General Purpose Probe

80PK-3A K-Type Surface Probe

80PK-4A K-Type Air Probe

80PK-5A K-Type Piercing Probe

80PK-6A K-Type Exposed Junction Probe

C50 Soft Case

(See authorized Fluke distributors for other accessories, thermocouple probes and connectors.)

Appendix A

These specifications apply to the thermocouple included with the thermometer.

Thermocouple Specifications

Type: K (Chromel vs. Alumel)

Operational Range: -40°C to 260°C (-40°F to 500°F)
continuous

NOTE

Operational limitations are due primarily to the thermal limitations of the thermocouple's insulation.

Initial Tolerances (with respect to NBS tables):

$\pm 1.1^{\circ}\text{C}$ (2°F) over the range of 0°C to 260°C (32°F to 500°F)

(Typically within 1.1°C or 2°F of NBS tables over the range of -40°C to 0°C or -40°F to 32°F)

Output: 25°C (77°F) corresponds to 1.00 mV (internal reference junction at 0°C)

Seebeck Coefficient: $40.50 \mu\text{V}/^{\circ}\text{C}$ at 25°C ($22.5 \mu\text{V}/^{\circ}\text{F}$ at 77°F)

Measurement Time (Time Constant): 2 seconds (for air at room temperature at one atmosphere of pressure moving with a velocity of 65 ft/sec)

Maximum Safe Contact Voltage: 24V ac rms or 60V dc

Maximum Temperature of Bead: 260°C (500°F)

Thermocouple Specifications (cont)

Cable length: 1.2m (4 ft)

Cable Insulation:

Material: Teflon

Maximum Temperature: 260°C (500°F)

CAUTION

Repeated sharp flexing can break the lead. To prolong lead life, avoid sharp bends in the lead, especially near the connector.

Insulation Rating: 1 kV between wire and outside of both layers of insulation

Conductors:

Type: K

Size: AWG #24 solid

Polarity and Color Coding:

Chromel: Yellow (+)

Alumel: Red (-)

Connector:

Type: Yellow mini-thermocouple connector with 7.9-mm (0.312-inch) blade spacing

Maximum Temperature: 200°C (392°F)