COLE PARMER INFRARED THERMOMETER OPERATING MANUAL

Models
N-08407-00 and N-08407-10

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CHAPTER 1.
INTRODUCTION

General
The hand-held IR Thermometer measures surface temperature without contact. The instrument collects the infrared energy radiated by a target object and computes its surface temperature. The instrument calculates temperature, running averages, maximums, minimums, and differentials, and presents them on a digital display in either degrees Celsius or Fahrenheit. An analog output enables data recording, instrumentation or process control, and/or remote display of temperature and emissivity. The IR Thermometer may be either battery or AC powered. Internal memory circuits store temperature data for later recall.

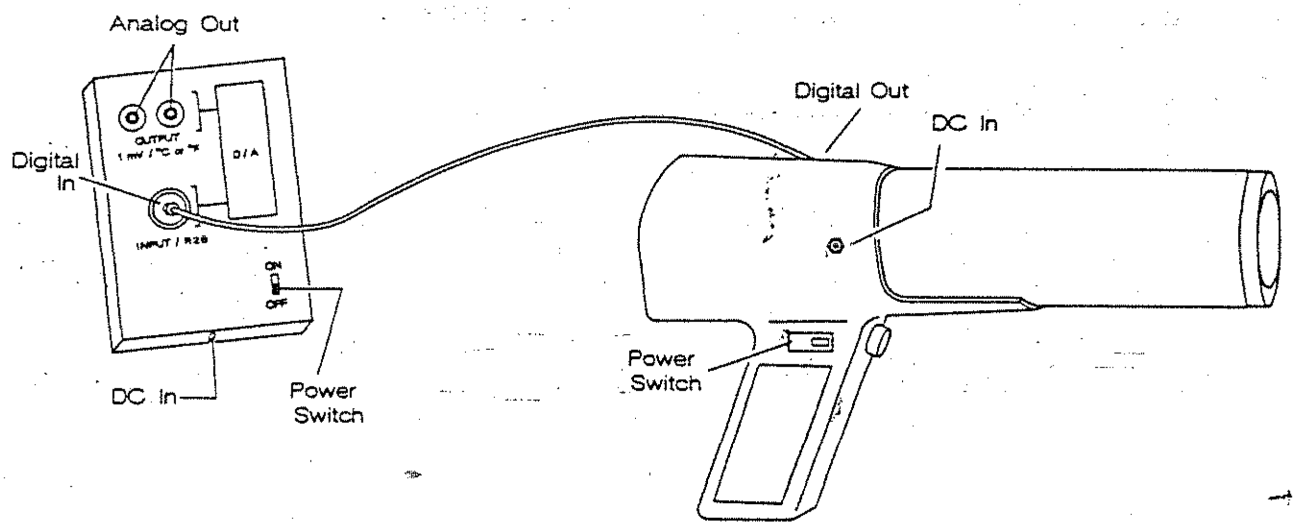


Figure 1. System Configuration

Optics
The optical filters of the IR Thermometer limit the wavelength of the IR spectrum reaching the instrument detector. This feature prevents measurement errors that may otherwise be induced by carbon dioxide, water vapor, sunlight, and material color.

Models

The IR Thermometer series is available in several models (identified by a serial number label on each instrument). The various models may be used for temperature measurement in general maintenance, product and process temperature monitoring, statistical quality control, and research. Each model includes a telescopic sight that increases aiming precision for small targets.

N-08407-00	Allows general-purpose measurement of smaller targets than at medium distances.
N-08407-10	High-resolution model for general-purpose measurement of smaller targets at greater.

All models include the Reflected Ambient Temperature Compensation feature.

IR Thermometer Specifications

General Operating

Accuracy	±1% of reading, ±1 digit
Repeatability	±0.5% of reading, ±1 digit
Emissivity	0.10 to 1.00 in 0.01 steps, digital setting and display
Reflected Ambient Temperature Input Range	1.0 to 3000°F (-17 to 1648°C)
Display Resolution	1.0 degree in TMP, MAX, MIN, DIF display 0.1 degree in AVG display below 1000°F (500°C)
Response Time	250 milliseconds
Power	9 Vdc

General Environment

Operating	32 to 120°F	0 to 50°C
Storage	-40 to 150°F	-40 to 60°C

Temperature Range

Model	Degrees F	Degrees C
N-08407-00	-20 to 2500	-30 to 1400
N-08407-10	-20 to 2500	-30 to 1400

Mechanical

Model	Length	Height	Width	Weight
N-08407-00	10" (25.4cm)	7.9" (20.0cm)	3.0" (7.6cm)	3.0 lbs (1.4kg)
N-08407-10	13.5" (34. cm)	7.9" (20.0cm)	3.0" (7.6cm)	3.0 lbs (1.4kg)

Data Interface

General Operating

Temp. Range °F and °C	-100 to 4095
Accuracy	±2mV @ 77°F, (25°C) ambient ±3mV for negative temperature readings
Repeatability	±1mV
Response Time	50 msec
Output Impedance	100 ohms
Power	9Vdc

Mechanical

Length	5.3" (13.5cm)
Height	1.5" (3.8cm)
Width	4.0" (10.2cm)
Weight	0.5 lb (0.23kg)

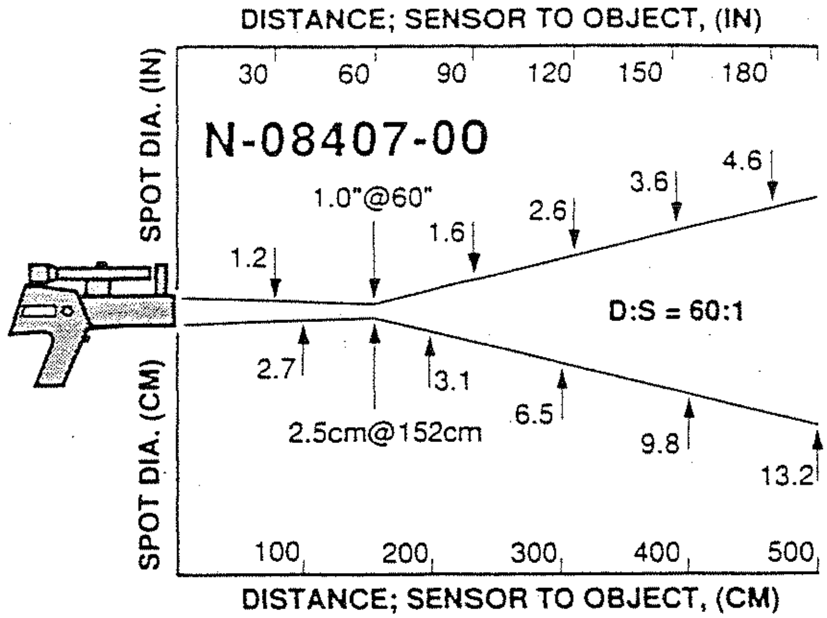
AC Adapter Specification

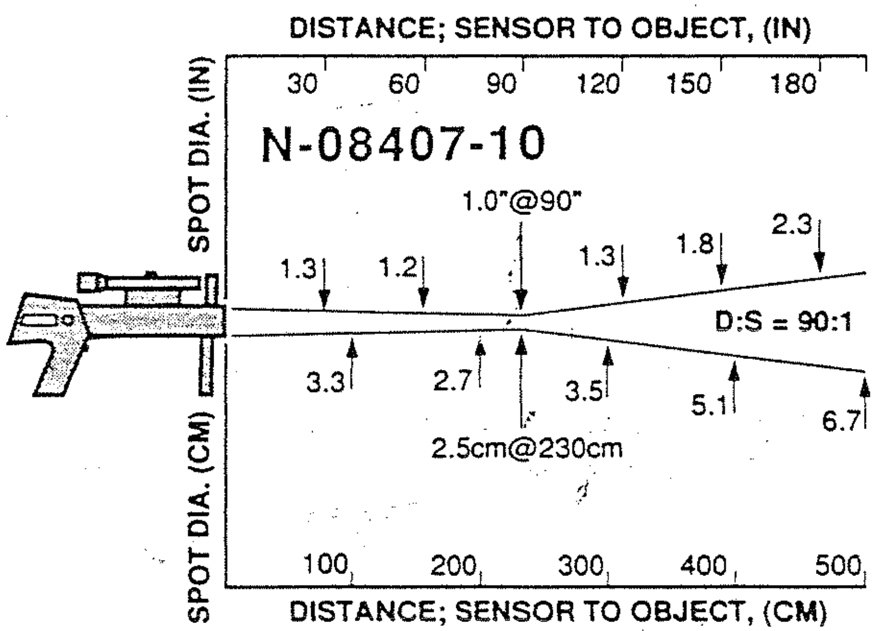
Voltage Output	10 Vdc min @ 100mA load, 18 Vdc max @ no load
Current	100 mA minimum
Connector	3.5 mm x 14 mm plug, tip positive

Note: AC adapter is an optional accessory, available in 110 VAC or 220 VAC versions. Please contact your local representative.

Optical

Model	Distance-to-Size-Ratio At Focal Point	Minimum Spot At Distance	Spectral Response (μ)
N-08407-00	60:1	1.0" (2.5 cm) @ 60" (152 cm)	8-14
N-08407-10	90:1	1.0" (2.5 cm) @ 90" (230 cm)	8-14


DISTANCE; SENSOR TO OBJECT, (IN)
30 60 90 120 150 180
SPOT DIA. (IN)
N-08407-00
1.0"@60"
1.2
1.6
2.6
3.6
4.6
D:S = 60:1
2.7
3.1
6.5
9.8
13.2
2.5cm@152cm
SPOT DIA. (CM)
100 200 300 400 500
DISTANCE; SENSOR TO OBJECT, (CM)


DISTANCE; SENSOR TO OBJECT, (IN)
30 60 90 120 150 180
SPOT DIA. (IN)
N-08407-10
1.0"@90"
1.3
1.2
1.3
1.8
2.3
D:S = 90:1
3.3
2.7
3.5
5.1
6.7
2.5cm@230cm
SPOT DIA. (CM)
100 200 300 400 500
DISTANCE; SENSOR TO OBJECT, (CM)

CHAPTER 2. OPERATION

General

The IR Thermometer is a powerful yet easy to use instrument. This chapter provides operating instructions and suggested techniques for various applications.

Display and Controls

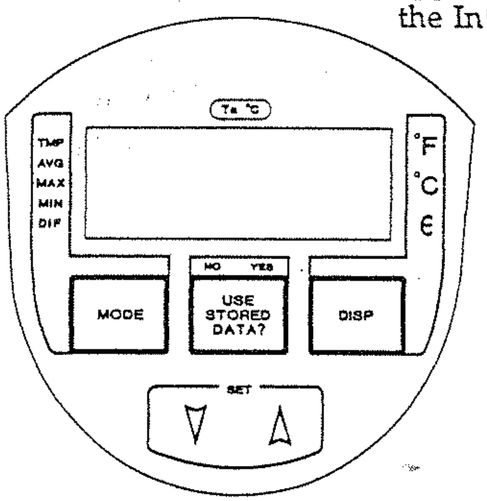
Power Switch	Slide switch: applies power to instrument; white visible when switch set to 'On'.
Trigger Switch	Alternate action switch: Pull to switch on and measure temperature, pull again to switch off, except laser version which is on only when switch is pulled.
DC IN	AC adapter connection jack.
MODE	Selects temperature data to be presented on the display. Also used to activate Ambient Temp Compensation mode when DISPLAY is set to Ta°C. The instrument computes and stores all data regardless of the display mode selected.
TMP	Current temperature measurement.
AVG	Average of all temperature measurements since the last time memory was cleared. The IR Thermometer adds each new reading to previous readings, then divides by total number of readings. For averages below 1000°F (538°C), the IR Thermometer calculates and displays temperatures to the nearest 0.1 degrees.
MAX	Maximum temperature since the last time memory was cleared.
DIF	Difference between minimum and maximum temperatures since the last time memory was cleared.
Ta°C	Reflected Ambient Temperature setting, in degrees Celsius. Indicates mode activated.
USE STORED DATA?	Toggles between YES and NO (as indicated on the display by ↓ over YES and NO on the panel).

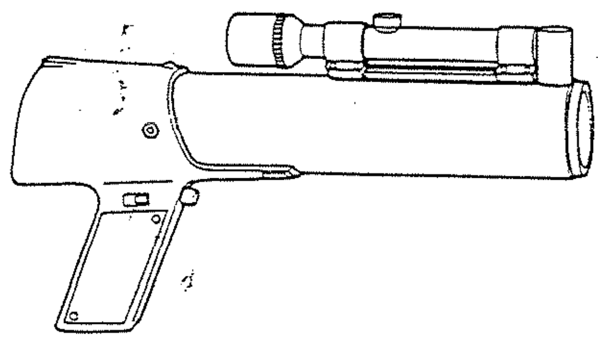
NO — The instrument clears memory immediately if it was previously set to YES. Also clears memory each time the trigger is pulled. CCCC appears on the display while memory is being cleared.

YES — Instrument accumulates temperature data in memory during each measurement cycle. Data remains in memory until either NO is selected or main power to the instrument is switched off.

DISPLAY — Selects Fahrenheit, Celsius, emissivity value, or Ta°C for display. ➤ on the display indicates the scale selected. The display indicates emissivity from 1.00 to 0.10 in 0.01 increments.

LO BAT — Appears on the upper left corner of the display when the battery voltage is too low to reliably power the instrument. Also appears when the AC adapter powers the IR Thermometer throug the Interface and the IR Thermometer Power Switch is off.





Interface Controls

On/Off Switch — Slide switch: Applies power to Interface: red LED lights when switch is set to ON. If the AC adapter is not being used and the LED does not light, replace the battery.

INPUT Connector — Interface cable connector for digital input from IR Thermometer.

OUTPUT Connector — Analog output for connection to instrumentation recorders: 1mV/degree.

DC IN Connector — Receptacle for connecting the AC adapter.

Set-Up

The IR Thermometer requires four basic operations to ready it for normal use: Power-on, emissivity select, scale select, and display select. To set-up the instrument (see Figure 2):

1. Slide the power Switch to 'On' (white on the switch shows). The display should be .95.

2. Press EMISSIVITY ↑ or ↓ to set desired emissivity if target emissivity is different than .95 (If you do not know your target emissivity, refer to Addendum II Emissivity Table).

3. Press SCALE SELECT until → points to F or C.

4. Press DISPLAY SELECT until → points to the desired display indication.

Operation

Aim the IR Thermometer at a target object and press the trigger to read its surface temperature. Initially, "CCCC" will appear for three seconds while unit self-calibrates. Then current temperature will appear on display. Press the trigger a second time to end the measurement cycle.

Interface Set-Up

To set-up the IR Thermometer Interface:

1. Using the 3 ft. (1M) interface cable, connect the Interface to the IR Thermometer.

2. Observing polarity (red positive, black negative) connect the output of the Interface to the desired instrumentation. The Interface output equals 1mV/degree or 1mV/0.01 units of emissivity.

3. Slide the IR Thermometer power switch to 'On'.

4. Set the Interface ON/OFF switch to 'On'. If desired, connect the AC adapter cord to the DC IN jack on the Interface and plug adapter into an AC source (see Figure 2).

5. Aim the IR Thermometer at a target object and press the trigger to read its surface temperature. Voltage output from the Interface will now represent the temperature indicated on the display.

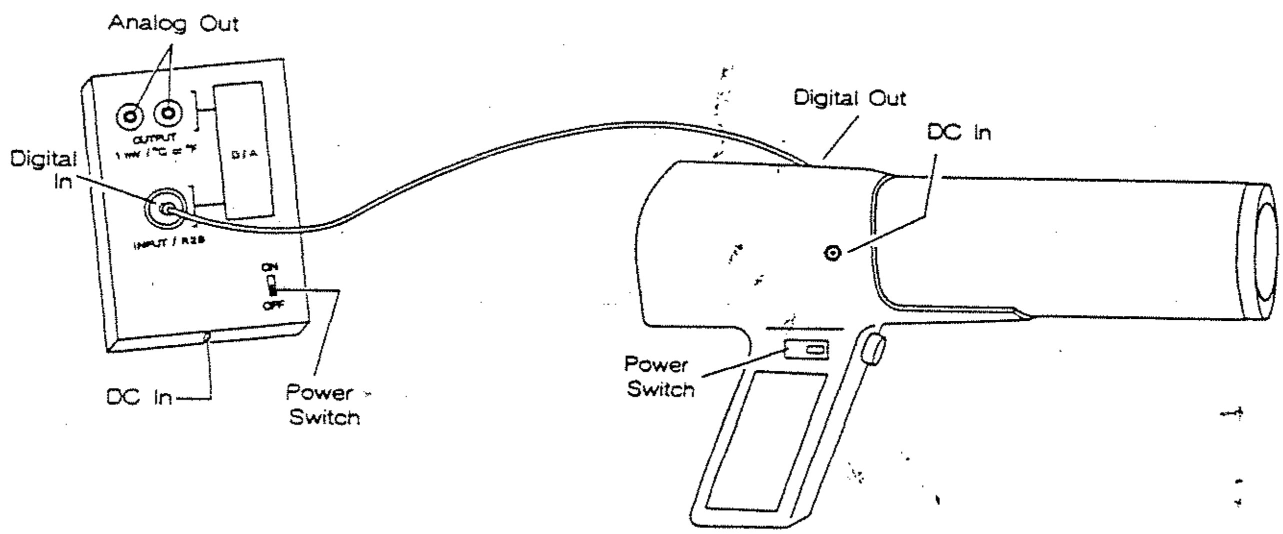


Figure 2. Display and Controls

Normal Operating Indications

Approximately 2 seconds after the trigger is pulled on, the Display Select arrow will flash twice per second and the display will indicate the target temperature. The IR Thermometer performs four measurements per second as long as its trigger is 'On'.

If the display indicates 8888, the target temperature is out of the instrument's range. CCCC on the display indicates the 2-second memory clear cycle is in progress.

Note: Keep the trigger 'On' longer than this 2-second 'clear' cycle to obtain a measurement reading.

The Display Select arrow will continue to flash twice per second as long as the trigger is 'On'.

When the trigger is pulled to 'Off', the IR Thermometer stops measuring temperature and displays the last reading, and the Display Select arrow stops flashing.

Operating Notes and Techniques

The IR Thermometer's basic operating features are simple to operate and use. The following paragraphs provide further insights and suggestions that will help the user to more effectively operate the instrument.

Emissivity Scale

When setting emissivity, the scale changes at a slow rate for the first 5 counts, then changes at a high rate.

Note: <u>Any</u> change to the emissivity setting clears all temperature data stored in memory.

Clearing Memory

If USE STORED DATA is set to NO, then memory is cleared when trigger pull starts a measurement cycle.

If USE STORED DATA is set to YES, clear memory by momentarily switching USE STORED DATA to NO.

Aiming

The IR Thermometer is equipped with either a nonparallax telescopic sight or open sights, depending on model.

To use the telescopic sight, hold the instrument at arm's length and simply center its cross hairs on the center of the target. A prism enables sighting down the axis of measurement, eliminating parallax errors.

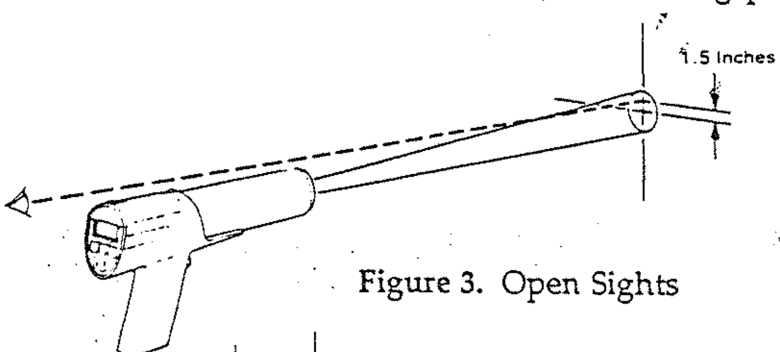


Figure 3. Open Sights

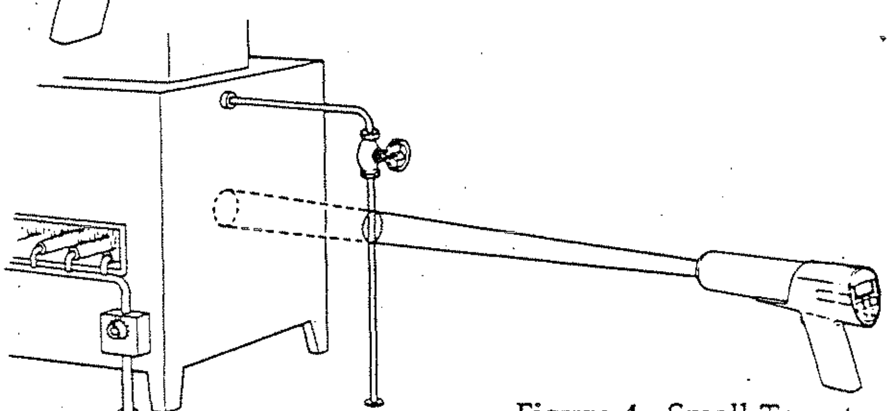


Figure 4. Small Target Measurement Considerations

Target Size/Field of View

Temperature measurements are independent of distance as long as the target size (when viewed from the IR Thermometer) is larger than the instrument's measurement spot size. This size directly relates to IR Thermometer-to-target distance. If the relative size of a target does not fill the IR Thermometer's field of view, the indicated temperature will be in error. Because the target does not fill the instrument field of view, the instrument collects target back-ground energy which influences the measurement.

The optical performance charts and tables (see IR Thermometer specifications) define measurement spot-size versus distance for each model.

Close Targets

Since the IR Thermometer design focal distances are 90" (230cm) or less, and 80" (2M), the temperature of targets measured closer may be as much as 2% high. It is recommended to measure at or beyond each respective focal distance, if optimum accuracy is desired.

Target Extreme Temperature Changes

When measuring very hot targets (e.g., in excess of 1500°F or 750°C) and then immediately attempting to measure a target at room temperature, the measurement will be inaccurate. Under these conditions, allow the instrument detector about 1 minute to cool. The instrument will then be ready to take reliable low temperature measurements.

Internal Temperature Considerations

The IR Thermometer, like any precision instrument, performs best when exposed to relatively constant, moderate ambient temperatures of 70 ±15°F (20 ±8°C). Its self calibration maintains very high measurement accuracy over its entire range, provided the instrument's internal temperature does not change too rapidly. If it is exposed to a major change in ambient temperature (i.e., ±45°F or ±25°C), allow at least one hour for it to stabilize at the new temperature to ensure accuracy. Smaller abrupt ambient changes require less time for stabilization.

Note: At very low ambient temperatures (i.e., 30°F or -1°C), the liquid crystal display responds to changes very slowly. Below 28°F (-2°C), the display appears to stop. No permanent damage will occur and the IR Thermometer will return to normal operation when warmed above 30°F (-1°C).

Comparison Measurements

When making comparison measurements on the same material, approximating its emissivity value will provide good results. Select a slightly low value to make the temperature differential slightly larger than actual. When trying to locate small temperature differences, set the emissivity value to 0.1 for maximum sensitivity. In this case, the absolute temperature measured will not normally be accurate.

Measurement Techniques

The IR Thermometer can be used in any one of four basic ways: Spot measurements, static surface scan, moving scan, and fixed point monitoring over time (see Figure 5).

For spot measurements (e.g., motor bearings, engine exhaust manifolds, etc.), simply aim the unit at the desired target and pull the trigger.

To measure temperature across a static surface (e.g., across an engine block, a smoke stack, cooling tower, etc.), aim the unit at a starting point and 'sweep' it across the surface. In this case, set the DISPLAY SELECT to AVG, MIN, or MAX as the application requires.

For moving surfaces (e.g., materials moving by conveyor), aim the unit at a fixed point and measure temperature as the materials move past. Or as the application requires, continually scan across the materials as they move past. For this measurement application, set the DISPLAY SELECT to AVG, MIN, or MAX as the application requires.

Certain applications may require monitoring target temperature over time. With its data recorder output, the IR Thermometer is particularly suited to this purpose. For this case, set the IR Thermometer on a tripod and connect the IR Thermometer Interface. Next, connect data recorder to the output of the Interface. The output signal equates to 1m/degree and correlates directly to the DISPLAY SELECT and SCALE SELECT settings. Thus, the IR Thermometer coupled to a data recorder (e.g. a strip recorder or X-Y plotter) will provide unattended monitoring.

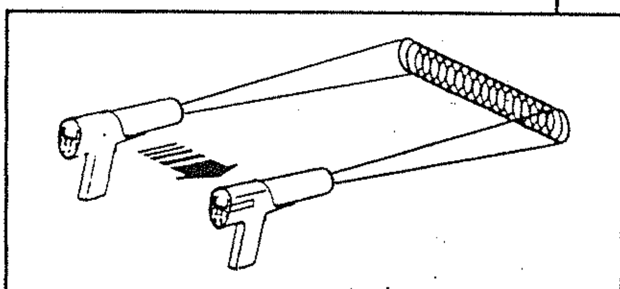
Use the IR Thermometer microprocessor intelligence to gather meaningful thermal data.

Large Area:

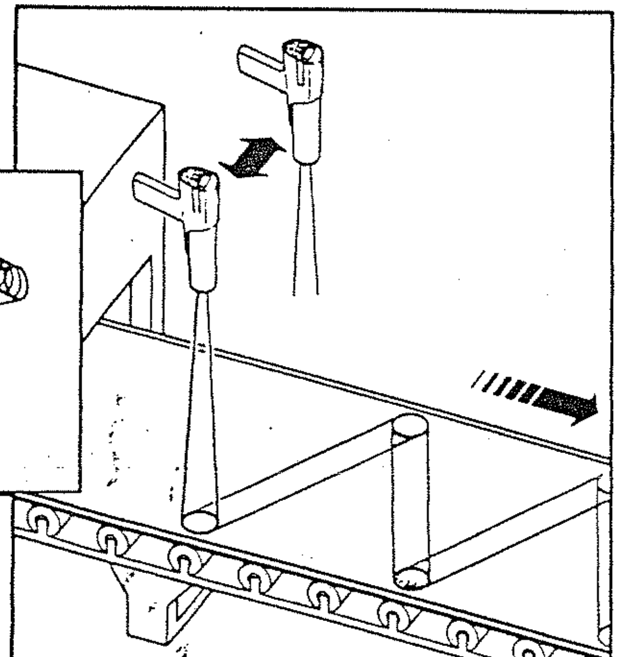
Scan a regular pattern slowly and evenly to gather thermal data. After scanning entire area, use AVG to read temperature most representative of entire surface. MAX and MIN show highest and lowest temperatures, which may give clues about insulation quality or uniformity of heater output. DIF reading provides additional data to analyze thermal characteristics of surface. All thermal data is stored in memory during measurement cycle for later recall and display.

Recording:

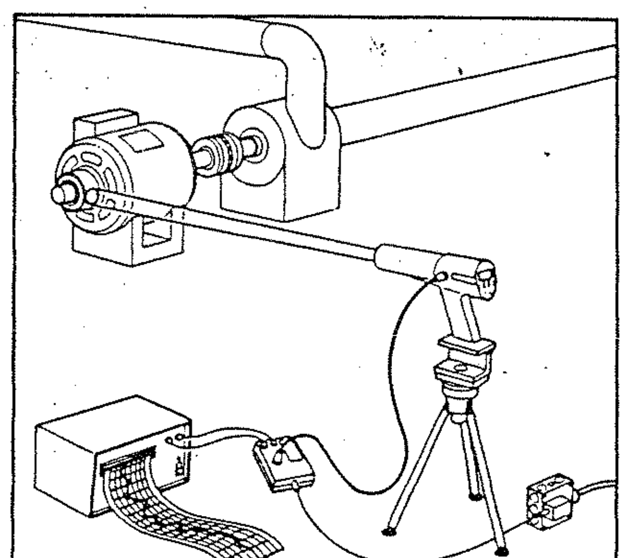
Use a chart recorder with the IR Thermometer to draw a thermal profile of a surface at a point in time, or show temperature variations over a time period. Select ∈ to record emissivity setting used to gather thermal data. Some recorders and data loggers have high and low limit alarms which can be used with the IR Thermometer for operator alert during a period of thermally critical monitoring. Hard copy thermal data provides credibility for justification of recommended solutions to temperature related problems, or certification that a thermally critical process was performed within specified temperature limits.



1. Scan a surface to record a thermal profile



2. Scan a moving surface to record a dynamic thermal profile



3. Monitor and record a temperature on a point over time

Figure 5. Data System Techniques

CHAPTER 3.
EMISSIVITY

General

The emissivity reference value of 1.00 is assigned to a blackbody. A blackbody is defined as a surface which emits the maximum amount of radiation at a specified temperature. 'Blackbody' refers to the radiant characteristic and surface finish of the material rather than to its visible color. An emissivity table in Appendix II lists typical values relative to a blackbody standard for some common materials.

Determining an Unknown Emissivity

The emissivity of most organic materials (e.g., cloth, wood, plastics, most paints) equals approximately 0.95. Metals with polished surfaces can have emissivities much lower than 1.0. If the emissivity of a material is in question, determine its value by using one of the methods that follows. For a detailed listing of emissivities, refer to Thermal Radiative Properties, Volumes 7 through 9, Y. S. Touloukian and D. P. Dewitt, IFI/ Plenum Data Corporation, Subsidiary of Plenum Publishing Company, 227 West 17th St., New York, NY 10011.

METHOD A

1. Heat a sample of the material in an oven to a known temperature (as measured with a calibrated, precision sensor).

2. Measure the surface temperature of the sample with the IR Thermometer. With the SCALE SELECT set to °F or °C, adjust the EMISSIVITY up (press ↑) or down (press ↓) during a measurement cycle until the display indicates the sample's actual temperature. Pull trigger to end the measurement cycle.

3. Set the SCALE SELECT to ∊ and read the emissivity value. Note and record this value for use whenever the same material is measured again.

METHOD B

1. For temperatures up to approximately 500°F (250°C), place a piece of common masking tape on the object to be measured.

2. With emissivity set to .92, measure and note the temperature of the masking tape (its emissivity is approximately .92). This process establishes the actual temperature of the object.

3. Proceed as in steps 2 and 3 in METHOD A, above.

METHOD C

1. For very high temperatures and if practical, drill a hole approximately 1.5" (3.5cm) in diameter and approximately 4" (10cm) deep in a sample of the object. This hole will act as a blackbody with an emissivity of approximately 1.0.

2. Set the IR Thermometer emissivity to 1.00 and measure the temperature of the 'blackbody' hole. The result is the correct object temperature.

3. Proceed as in steps 2 and 3 in METHOD A, above.

METHOD D

1. When a portion of a material sample can be coated, paint it with a dull black paint, 'mold-release', or spray-on baking soda deodorant. These materials exhibit an emissivity of approximately 1.0.

2. Set the IR Thermometer emissivity to 1.00 and measure the temperature of the coated portion of the material sample. The result is the correct object temperature.

3. Proceed as in steps 2 and 3 in METHOD A, above.

CHAPTER 4.
USE OF REFLECTED ENERGY COMPENSATION MODE

When an object has an emissivity below 1.0 it will reflect the external temperature (Ta) to which it is exposed. This is added to its own emitted energy. If the external ambient temperature is the same value as the internal temperature of the IR Thermometer, there is no need to input this value as it is automatically and continuously measured. However, in many industrial environments the surrounding environment (machines, furnaces, or other heat sources) have an average value much higher than that of the internal temperature of the IR Thermometer. Table 1 illustrates the effect of hotter surrounding environments (and emissivity) on measurement accuracy, with and without Reflected Ambient Temperature (Ta) compensation.

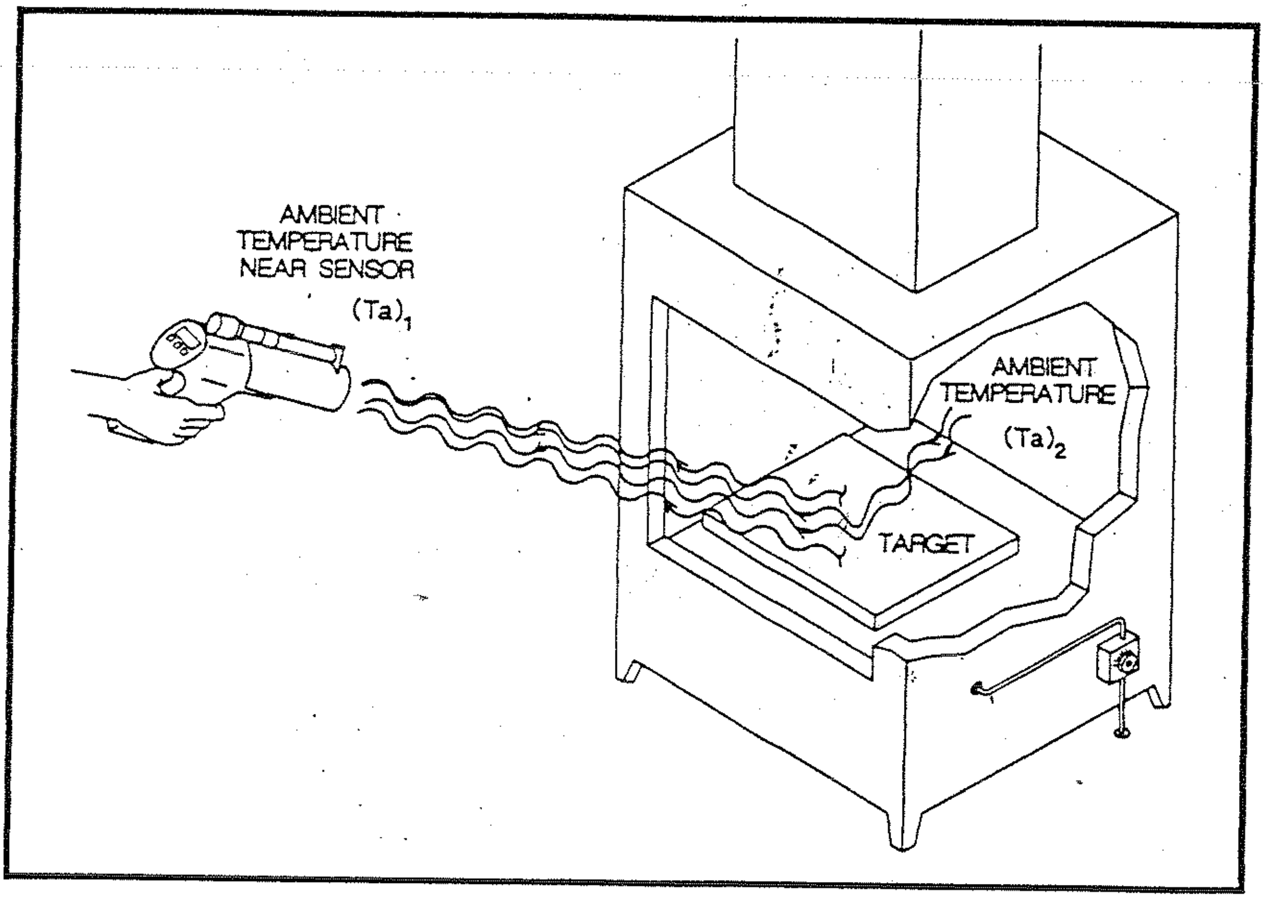


Figure 6. Reflected Energy

Table 1 Effect of Reflected Energy Compensation Mode on Measurement Accuracy for Various Considerations

Actual Target Temp		Emissivity	Reflected Temp (T AMB)		Indicated Temp W/O T Amb Compensation		Indicated Temp W/T Amb Compensation	
200°F	93°C	.8	80°F	27°C	200°F	93°C	200°F	93°C
200°F	93°C	.8	100°F	38°C	203°F	95°C	200°F	93°C
200°F	93°C	.8	300°F	149°C	250°F	121°C	200°F	93°C
200°F	93°C	.6	300°F	149°C	321°F	161°C	200°F	93°C

Note: Internal Temperature of the IR Thermometer assumed to be 80°F (27°C).

Explanation:

1. No error if IR Thermometer internal temperature and ambient temperature near target are the same.
2. Error of 3°F (2°C) when ambient near target is 20°F (11°C) higher than ambient of thermometer.
3. Increasing error with increasing difference between target and sensor ambient temperatures.
4. Increasing error with decreasing emissivity.

To overcome erroneous readings that may result, allowance is made for the ambient temperature input. To determine a practical value of reflected ambient temperature, set the emissivity to 1.0. Set the MODE to AVG. Then, pan the instrument across the target's field-of-view (objects and surfaces surrounding the target) several times. Read the average temperature value in °C only. This is the value you should enter as the reflected ambient temperature. Default temperature of ambient value is 25°C.

To Input The Ambient Temperature:

1. Operate the DISP button until ▲ below Ta°C is seen on the display.
2. Operate the + or - controls to set the desired external reflected ambient temperature (°C only). The range for this control is between -17° to +1648°C.
3. Operate the MODE button until ^ is seen above the triangle (▲).
4. Operate DISP to the desired scale (°F, °C, or ∊). The ▲ will disappear.
5. Operate MODE to desired function.
6. Measure target as needed.

To Return To Automatic Internal Temperature As A Reference:

1. Operate DISP to Ta°C position. ▲ appears.
2. Operate MODE until ^ symbol disappears from display.
3. Operate DISP to desired scale (▲ will disappear).

CHAPTER 5.
THEORY OF OPERATION

General

This chapter presents generalized theory of the IR Thermometer operation. It intends only to provide a basic understanding of the function of the IR Thermometer as an instrument for measuring infrared radiation.

Temperature Measurement

The IR Thermometer focuses infrared (IR) radiation emitted from a target object onto a thermopile detector. The models use a cassegrainian mirror system.

When the trigger is pulled, the microprocessor places a mylar flag in front of the detector (see Figure 7). This flag, whose temperature is determined by the ambient sensor, serves as a calibration reference for the detector. The flag is then removed and the IR radiation from the target object is allowed to reach the detector.

Detector Signal Processing

A detector amplifier increases the thermopile signal level and directs it to the analog-to-digital converter. The microprocessor compares the signal digital value with calibration values stored permanently in program memory. Using the comparison results, it then computes the temperature that equates to the detector signal. Display control settings (i.e., Display Select, Scale Select, Use Stored Data, and Emissivity) tell the microprocessor which calculations to use to display the correct value. The data storage holds temporary values such as summed measurement data.

Signal Processing in Ambient Temperature Compensation Mode

If the reflected Ambient Temperature Compensation mode is activated, the microprocessor uses the value Ta, as set by the user, in computing the true target temperature. This results in optimum absolute accuracy for lower emissivity targets which are reflecting energy due to some ambient Ta not equal to the temperature of the internal ambient temperature sensor.

Display and Output

After the microprocessor calculates the appropriate value, it applies it through the display decoder/driver to the display. The signal from the decoder/driver is available at the output connector for use by the Interface.

Data Interface

The IR Thermometer Interface contains a microprocessor and a digital-to-analog converter (DAC). The microprocessor de-multiplexes the signal from the IR Thermometer and applies the result to the DAC for decoding. The DAC generates an output scaled for 1 mV/degree. This output is made available at binding post terminals for connection to instrumentation recorders.

AC/DC Power

'Transistor radio' type 9 volt batteries power the IR Thermometer and the IR Thermometer Interface. Internal regulation produces 5 Vdc for use by instrument circuits. Optionally, either the IR Thermometer or the IR Thermometer Interface may be powered by an AC Adapter. The AC adapter plugs into a standard outlet and its cord plugs into the DC IN jack on the side of the IR Thermometer or the Interface case. When the IR Thermometer and the Interface are connected together, the AC adapter should be plugged into the Interface. Plugging the AC adapter into the IR Thermometer will not power the Interface, however.

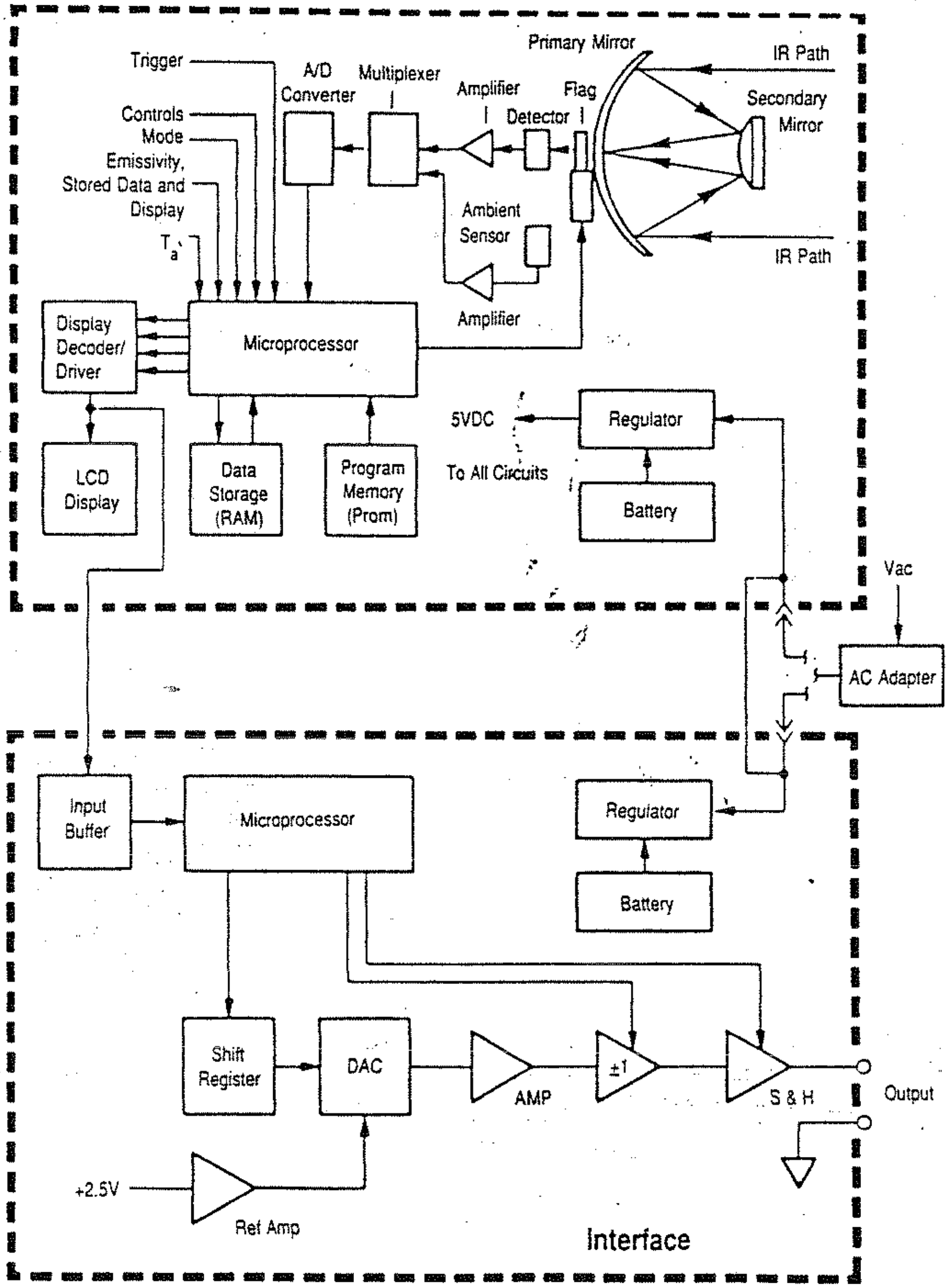


Figure 7.
Block Diagram

CHAPTER 6
USER MAINTENANCE

General
This chapter contains information for the general care of the IR Thermometer. It also provides instructions for troubleshooting the simple problems that may be experienced.

Battery Installation and Replacement
The IR Thermometer and Interface use standard 'transistor radio' type 9 volt batteries. For normal operation, the Data System may be operated continuously for 7 to 8 hours on new alkaline batteries (45 hours on lithium batteries.)

Battery Installation

To replace the battery in the IR Thermometer:
1. Slide the Power Switch to 'Off'.
2. Remove the 2 screws that secure the battery compartment cover and remove the cover (see Figure 8).
3. Unsnap the power connector from the battery and remove the battery.
4. Install the new battery, close the cover and screw it in place.

Interface Battery Installation

To replace the battery in the Interface:
1. Set the ON/OFF switch to 'Off'.
2. Remove the battery compartment cover (see Figure 8).
3. Unsnap the power connector from the battery and remove the battery.
4. Install the new battery and close the compartment cover.

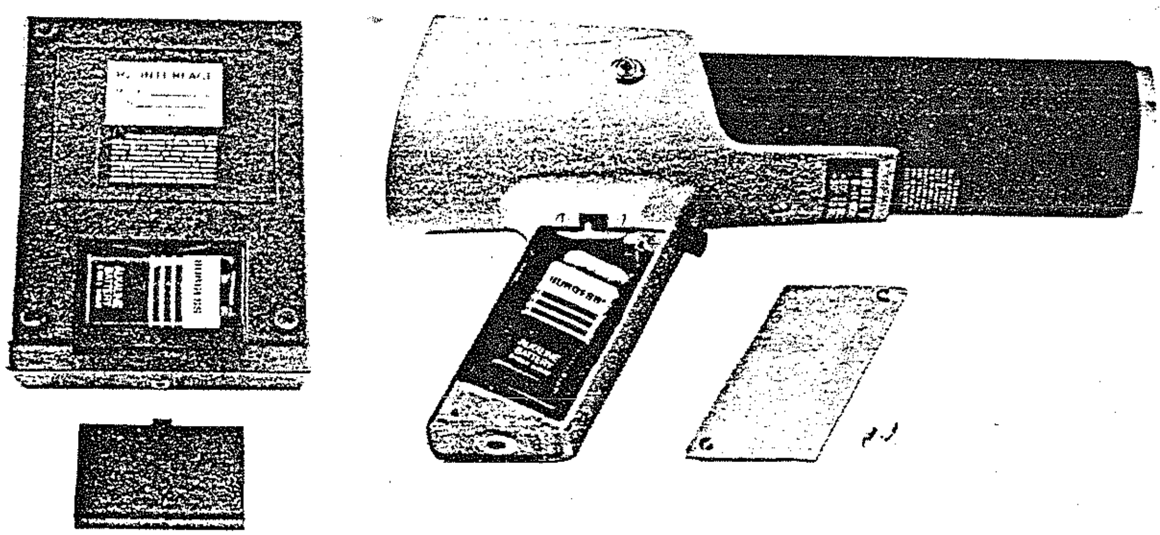


Figure 8. Battery Compartments

Front Protective Film Replacement

The plastic film over the end of the IR Thermometer barrel prevents dust and dirt from contaminating the instrument optical system. If this film becomes torn or punctured, replace it as soon as possible. Use only factory-supplied replacement film.

Note: The IR Thermometer is calibrated with the protective film in place. Unreliable temperature readings will result if the unit is operated without the film in place.

To replace the protective film:

1. Remove the barrel and ring (see Figure 9).
2. Remove and discard the damaged film.
3. Place the replacement film over the barrel end and partially install the end ring. Pull the film to remove any wrinkles.
4. Press the end ring evenly over the new film and back into place on the barrel. Ensure that the ring is fully sealed.
5. Using a sharp knife or razor blade, trim excess film from around the barrel.

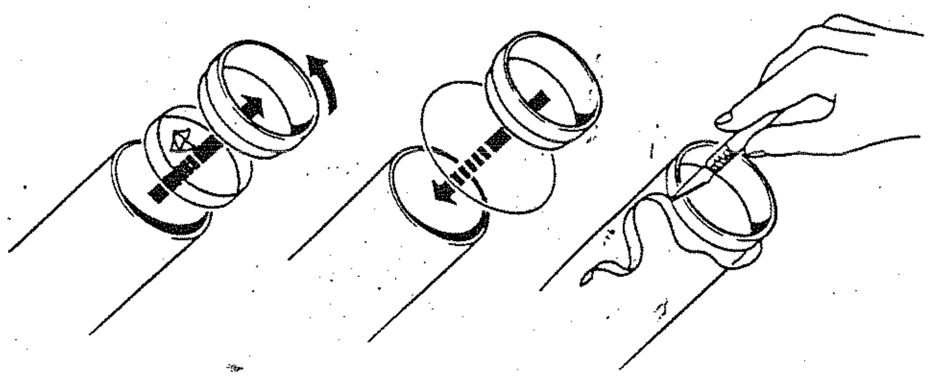


Figure 9. Protective Film Replacement

Cleaning

To clean the IR Thermometer, simply use soap and warm water or a mild commercial cleaner. Wipe the housing exteriors with a damp sponge or soft rag. Use a soft rag to gently wipe the display and, on the IR Thermometer, the protective film.

Troubleshooting

The IR Thermometer generally provides dependable operation in an industrial environment. However, as with even the best of products, difficulties may occasionally be experienced. Table 2 lists typical fault symptoms together with their probable causes and what can be done to correct them.

Table 2. Troubleshooting

Symptom	Probable Cause	What To Do
No display when Power switch is slid to ON	Bad battery or poor battery contact	Replace battery.
Display fades or no display when trigger is pulled	Bad battery or poor battery contact	Replace battery.
Display indicates CCCC	Normal indication: shows when trigger is first to begin measurement cycle	Wait a few seconds for temperature indication.
Display only indicates 3 arrows and decimal	Normal indication: shows if EMISSIVITY a ↓ or ↑ has not yet been pressed	Press EMISSIVITY or ↑ to set desired emissivity.
Display 'locked' or shows erratic numbers (e.g., Oc15)	Bad battery or poor battery contact	Replace battery.
	Electronics problem	Press SCALE SELECT until → points to ∊, then press ↓ and ↑ at the same time to reset the microprocessor (display should flash 1.00), then follow SET-UP procedures in Chapter 2. If fault persists, turn in to repair facility.
Erroneous temperature readings	Wrong emissivity value set	Look up the emissivity value for the target material in the Appendix and set accordingly.
	Instrument out of calibration	Send IR Thermometer to calibration facility.
IR Thermometer and Interface inoperative when interconnected	Bad battery in Interface	Replace Interface battery.
	Bad AC adapter	Replace AC adapter or test with battery.

Table 2. Continued

Symptom	Probable Cause	What To Do
No output from Interface	No battery in Interface and AC adapter connected to IR Thermometer.	Connect AC adapter to Interface.
	Bad interconnect cable	Replace cable.
	Bad Interface electronics	Send Interface to repair facility.
Interface output does not track nor correspond to IR Thermometer	Interface cable not properly connected	Check cable connection between IR Thermometer and Interface.
	Bad Interface electronics	Send Interface to repair facility.
Instrumentation recorders connected to Interface do not track Interface output	Poor connection to Interface terminals	Check connection.
	Input impedance to recorder is too low	Use instrumentation recorders with a high input impedance (at least 10 MOhm).
Random segments on LCD	Internal Problem	Send to repair facility.

APPENDIX I
GLOSSARY

Blackbody: A temperature radiator of uniform temperature whose emitted energy in all parts of the spectrum is the maximum obtainable from any temperature radiator at the same temperature. "Black" in the term 'blackbody' implies total absorption of energy.

Emissivity: Ratio of energy radiated by a surface to the energy radiated by a blackbody at the same temperature.

Field of View: The angle in degrees over which the instrument gathers IR energy.

Infrared (IR) Radiation: Any radiant energy with wavelengths between 0.7 and 1000 microns. The level of IR radiation from an object is directly related to its temperature. IR radiation wavelengths are longer than those of visible light (see Figure 10).

Minimum Spot Size: The smallest spot an instrument can measure at a given focal distance. This spot measures a minimum 90% energy.

Spectral Response: The range of wavelengths in microns to which an instrument responds.

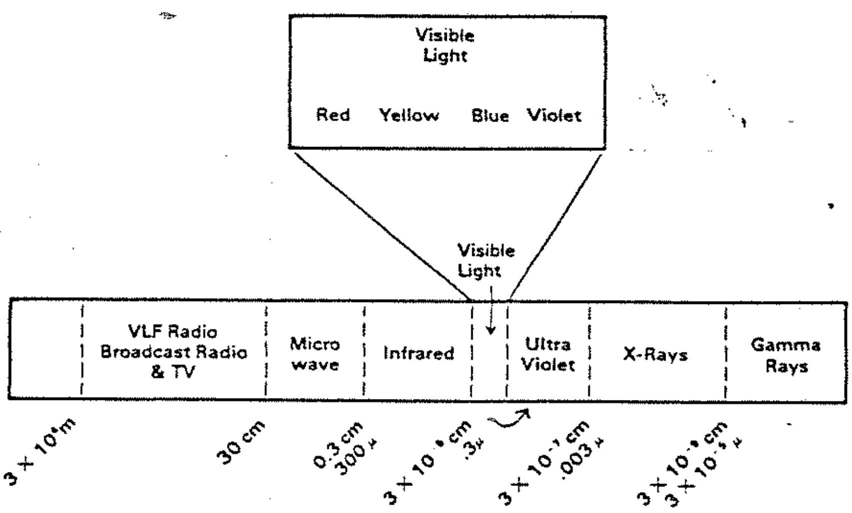


Figure 10. Electromagnetic Spectrum

APPENDIX II
EMISSIVITY TABLE

This table provides only a guideline for estimating the emissivity of various common materials. Actual emissivity - especially of metals - can vary greatly depending on surface finish, oxidation, or the presence of contaminants. Also, emissivity of IR radiation for some materials varies with wavelength and temperature. Therefore, this table lists emissivity values for three different wavelength bands. Follow the procedures in Chapter 3 for determining exact emissivities for most applications.

METALS

Material	Emissivity		
	8-14µ	2.2µ	5.1µ
Aluminum			
Unoxidized	0.02-0.1	0.02-0.2	0.02-0.2
Oxidized	0.2-0.4	0.2-0.4	0.2-0.4
Alloy A3003,			
Oxidized	0.3	0.4	0.4
Roughened	0.1-0.3	0.2-0.6	0.1-0.4
Polished	0.02-0.1	0.02-0.1	0.02-0.1
Brass			
Polished	0.01-0.05	0.01-0.05	0.01-0.05
Burnished	0.3	0.4	0.3
Oxidized	0.5	0.6	0.5
Carbon			
Unoxidized	0.8-0.9	0.8-0.9	0.8-0.9
Graphite	0.7-0.8	0.8-0.9	0.7-0.9
Chromium	0.02-0.2	0.05-0.3	0.03-0.3
Copper			
Polished	0.03	0.03	0.03
Roughened	0.05-0.1	0.05-0.2	0.05-0.15
Oxidized	0.4-0.8	0.7-0.9	0.5-0.8
Gold	0.01-0.1	0.01-0.1	0.01-0.1
Haynes			
Alloy	0.3-0.8	0.6-0.9	0.3-0.8
Inconel			
Oxidized	0.7-0.95	0.6-0.9	0.6-0.9
Sandblasted	0.3-0.6	0.3-0.6	0.3-0.6
Electropolished	0.15	0.25	0.15
Iron			
Oxidized	0.5-0.9	0.7-0.9	0.6-0.9
Unoxidized	0.05-0.2	0.1-0.3	0.05-0.25

Metals - continued

Material	Emissivity		
	8-14μ	2.2μ	5.1μ
Rusted	0.5-0.7	0.6-0.9	0.5-0.8
Molten	—	0.4-0.6	—
Iron, Cast			
Oxidized	0.6-0.95	0.7-0.95	0.65-0.95
Unoxidized	0.2	0.3	0.25
Molten	0.2-0.3	0.3-0.4	0.2-0.3
Iron, Wrought			
Dull	0.9	0.95	0.9
Lead			
Polished	0.05-0.1	0.05-0.2	0.05-0.2
Rough	0.4	0.5	0.4
Lead			
Oxidized	0.2-0.6	0.3-0.7	0.2-0.7
Magnesium	0.02-0.1	0.05-0.2	0.03-0.15
Mercury	0.05-0.15	0.05-0.15	0.05-0.15
Molybedenum			
Oxidized	0.2-0.6	0.4-0.9	0.3-0.7
Unoxidized	0.1	0.1-0.3	0.1-0.15
Monel (Ni-Cu)	0.1-0.14	0.2-0.6	0.1-0.5
Nickel			
Oxidized	0.2-0.5	0.4-0.7	0.3-0.6
Electrolytic	0.05-0.15	0.1-0.2	0.1-0.15
Platinum	0.02-0.3	0.1-0.4	0.05-0.03
Black	0.9	0.95	0.9
Silver	0.02	0.02	0.02
Steel			
Cold-Rolled	0.7-0.9	—	0.8-0.9
Ground Sheet	0.4-0.6	0.6-0.7	0.5-0.7
Polished Sheet	0.1	0.2	0.1
Molten	—	0.25-0.4	0.1-0.2
Oxidized	0.7-0.9	0.8-0.9	0.7-0.9
Stainless	0.1-0.8	0.2-0.9	0.15-0.8
Tin (Unoxidized)	0.05	0.1-0.3	0.05
Titanium			
Polished	0.05-0.2	0.2-0.5	0.1-0.3
Oxidized	0.5-0.6	0.6-0.8	0.5-0.7
Tungsten	0.03	0.1-0.6	0.05-0.5
Polished	0.03-0.1	0.1-0.3	0.05-0.25
Zinc			
Oxidized	0.1	0.15	0.1
Polished	0.02	0.05	0.03

NON-METALS

Material	Emissivity		
	8-14μ	2.2μ	5.1μ
Asbestos	0.95	0.8	0.9
Asphalt	0.95	—	0.95
Basalt	0.7	—	0.7
Carborundum	0.9	0.95	0.9
Ceramic	0.95	0.8-0.95	0.85-0.95
Clay	0.95	0.8-0.95	0.85-0.95
Concrete	0.95	0.9	0.9
Cloth	0.95	—	0.95
Glass			
Plate	0.85	0.2	0.98
"Gob"	—	0.4-0.9	0.9
Gravel	0.95	—	0.95
Gypsum	0.8-0.95	—	0.4-0.97
Ice	0.98	—	—
Limestone	0.98	—	0.4-0.98
Paint (non-al.)	0.9-0.95	—	—
Paper (any color)	0.95	—	0.95
Plastic (opaque, over 20 mils)	0.95	—	0.95
Rubber	0.95	—	0.9-0.95
Sand	0.9	—	0.9
Snow	0.9	—	—
Soil	0.9-0.98	—	—
Water	0.93	—	—
Wood, Natural	0.9-0.95	—	0.9-0.95