IRCON®

Fluke Process Instruments

MODLINE®

INSTALLATION and OPERATION MANUAL

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The device complies with the requirements of the European Directives.
EC - Directive 2004/108/EC (EMC)

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Cautions and Warnings

For installing, operating, and servicing this instrument, please observe all cautions and warnings that are located throughout this manual.

CAUTION

Example of a Caution.

WARNING

Example of a Warning.

CE Compliance Information

CAUTION

Interchanging non-CE-approved components such as older sensing heads, indicators, PC boards, and cables will not maintain compliance to the CE Directive.

MODLINE 4 INFRARED THERMOMETER

WARRANTY

IRCON, Inc. warrants equipment manufactured by it to be free from defects in materials and workmanship for a period of one year from the date of shipment by IRCON. Customer-paid repairs are warranted for 90 days from date of shipment. If within such period any such equipment shall be proved to IRCON'S satisfaction to be so defective, such equipment shall be repaired or replaced at Ircon's option, provided the defective equipment is returned to Ircon, transportation charges prepaid by purchaser. This warranty shall not apply **(a)** to equipment not manufactured by Ircon, **(b)** to equipment which shall have been repaired or altered by others than Ircon so as, in its judgement, to affect the same adversely, or **(c)** to equipment which shall have been subject to negligence, accident, or damage by circumstances beyond Ircon's control or to improper operation, maintenance or storage, or to other than normal use or service. With respect to equipment purchased by IRCON but not manufactured by Ircon, the warranty obligations of Ircon shall in all respects conform and be limited to the warranty actually extended to Ircon by its supplier (the manufacturer). The foregoing warranties do not cover reimbursement for transportation, removal, installation, or other expenses which may be incurred in connection with repair or replacement.

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Anything to the contrary herein contained notwithstanding, ***IRCON, IT'S CONTRACTORS AND SUPPLIERS OF ANY TIER, SHALL NOT BE LIABLE IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY) OR OTHERWISE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES WHATSOEVER.*** The remedies of the purchaser set forth herein are exclusive where so stated and the total cumulative liability of Ircon, it's contractors and suppliers of any tier, with respect to this contract or anything done in connection therewith such as the use of any product covered by or furnished under the contract, whether in contract, in tort (including negligence or strict liability) or otherwise, shall not exceed the price of the product or part on which such liability is based.

CAUTION

Risk of Personal Injury

When this instrument is used on a critical process where failure of this instrument could cause personal injury or property damage, **the user must provide a redundant device or system that will initiate a safe process shutdown .** The user should also follow NEMA safety guidelines in the Appendix of this manual.

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Section 1 – INTRODUCTION

1.1 GENERAL DESCRIPTION

MODLINE 4 is an infrared thermometer with a built-in two wire transmitter. Power it up with a 16 to 40 volt direct current source and you get a 4 to 20 mA current (maximum) that varies linearly with temperature. You can use this current to operate a 4 to 20 mA indicator, recorder, controller or datalogger – or a combination of devices in the series. Figure 1.1 shows the basic electrical circuit.

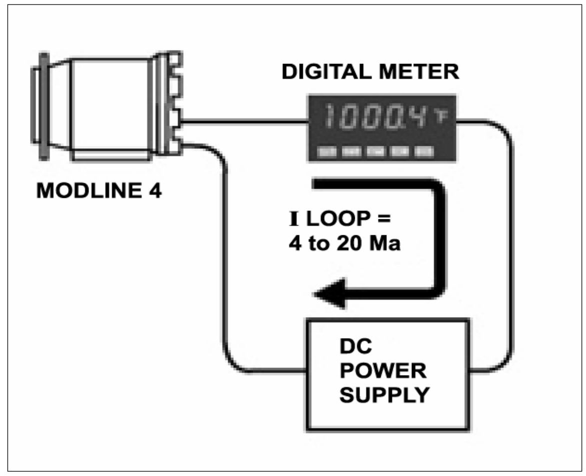


Fig. 1.1 - BASIC MODLINE 4 ELECTRIC CIRCUIT

This instrument is built for long, trouble-free service in even the harshest environments. Everything is packaged in sealed aluminum casting rated NEMA 4. The instrument can be ordered with a water-cooled casting for operation in high ambient temperatures.

The lens is recessed and sealed in the front of the casting. A screw-on back cover with torquing slots gives access to the adjustments and connections (see figure 1.2). A 1/2 inch NPT conduit hub is provided for wiring. NOTE: The back cover of the water-cooled enclosure has a pair of torquing studs.

Fig. 1.2 - MODLINE 4 REAR VIEW (WITH COVER REMOVED) and FRONT VIEW
Note: standard enclosure shown.

The MODLINE 4 is easy to install, operate and maintain. The lens is pre-adjusted and sealed so you don't have to make optical adjustments. Just choose a clear sight path with no obstructions, aim the sensor at the object you want to measure and read the temperature on your indicator.

The controls on the back panel allow you to adjust for emissivity of the material you are measuring and for the most suitable response time for your process. If the instrument includes a peak picker (block D of model number = 1), an additional control is provided for peak picker decay time. As long as your process stays the same, you will make these adjustments only once when you set up the instrument.

The high-level current signal (20 mA maximum) minimizes noise problems often associated with long cable runs. Twisted pair cable with an overall shield is all you need for most applications.

Seven different MODLINE 4 series that differ in spectral responses, cover a wide variety of processes. Temperature ranges covering 0 to 2500°F and 0 to 1300°C are available. *Note:* General illustrations in this manual that show the standard MODLINE 4 casting also apply to instruments with water-cooled castings.

1.2 HOW IT WORKS

The MODLINE 4 works on a simple principle. A heated object radiates infrared energy, and the intensity of radiation depends on the temperature of the object. By measuring the radiation intensity, it is possible to measure the temperature without contacting the object.

Fig. 1.3 shows a MODLINE 4 series with a digital meter across a DC power supply. The current in this circuit is determined by the MODLINE 4.

Infrared radiation enters the lens of the MODLINE 4 and is focused on an infrared detector. The detector converts infrared energy to an electrical signal that varies with the intensity of infrared radiation. This signal is amplified, linearized, and scaled to the desired temperature range by the MODLINE 4 electronic circuits. The resulting output current causes the pointer to deflect on the meter. If the meter scale is matched to the MODLINE 4 range, it's a simple matter to read temperature values directly from the scale.

Fig. 1.3 shows how the MODLINE 4 measures a change in temperature. Assume the MODLINE 4 is scaled for the 500 to 1500°F range. The circuit current is 4 mA when the MODLINE 4 is viewing a 500°F target and 20 mA when viewing a 1500°F target. The current varies linearly between 4 and 20 mA for temperatures between 500 and 1500°.

In Fig. 1.3a, the target temperature is 500°F. The target will radiate a certain intensity of infrared energy at this temperature. When the MODLINE 4 senses this radiation, it causes 4 mA current in the meter. The pointer rests at the lowest scale limit (500°).

Figures 1.3b and 1.3c shows what happens when target temperatures increases. The MODLINE 4 detects more infrared radiation, and the meter current increases to display higher temperature readings.

Summarizing the action, the MODLINE 4 provides a DC current proportional to the infrared energy it senses. This current can be fed through a variety of current-sensitive devices to indicate temperature or provide a desired control action.

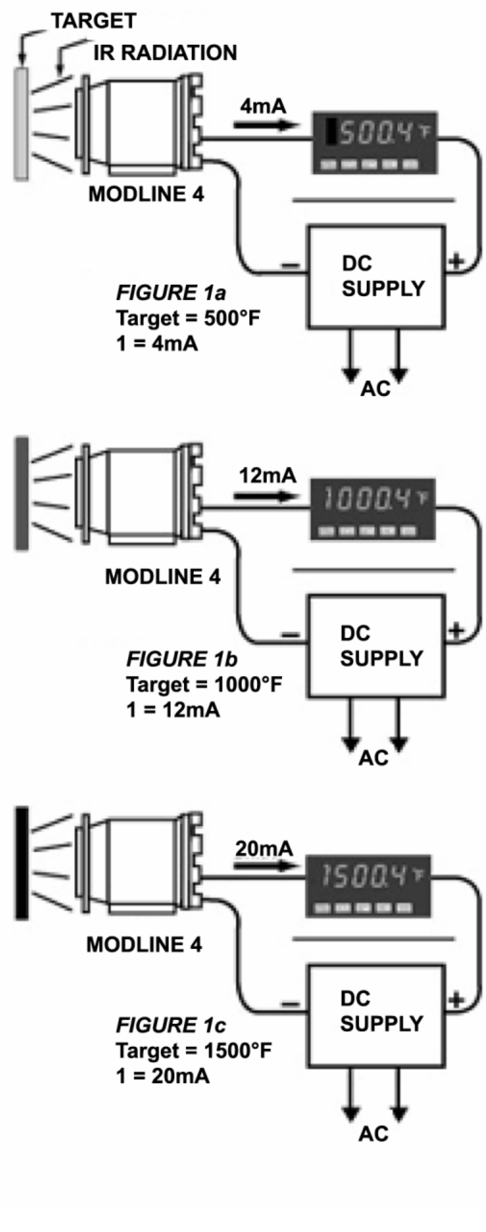


FIG. 1. 3 - BASIC OPERATING PRINCIPLE OF MODLINE 4 INSTRUMENT

1.3 OPERATING WAVELENGTHS

It takes a whole family of instruments to cover a wide range of measurement applications. MODLINE 4 features such a family-seven series operating at distinct infrared wavelengths. Each series includes the temperature spans that are common for the applications involved.

The wavelength regions selected for the various MODLINE 4 series are listed in Table 1.1. This table also summarizes some of the primary applications for these ranges.

TABLE 1.1 – SUMMARY OF MODLINE 4 SERIES

Series	Standard Ranges	Wavelength	Primary Applications
43	120 to 400°F 150 to 500°F 200 to 600°F 300 to 1000°F 50 to 200°C 100 to 400°C 150 to 500°C	3.43 ± 0.07 microns	Measures thin, clear films of C-H Type plastics such as polyethylene, polypropylene, polystyrene, vinyls, and nylon. Also ideal for paints and organics such as waxes and oils.
44 **22**	0 to 200°F 0 to 500°F 0 to 1000°F 0 to 100°C 0 to 250°C 0 to 600°C	8 to 14 microns	Ideally suited to all types of very low temperature applications such as print drying, food, wood, paper and textile processing, vacuum forming, and infrared heating.
45	500 to 1000°F 500 to 2500°F 300 to 800°C 300 to 1300°C	3.7 to 4.0 microns	Measures subsurface glass temperature. Good unit to see though hot gasses and flame.
46	500 to 1000°F 600 to 1400°F 250 to 600°C 350 to 800°C	2.0 to 2.6 microns	All types of medium temperature applications involving metals.
47	200 to 1000°F 500 to 1500°F 500 to 2500°F 100 to 600°C 300 to 850°C 300 to 1300°C	4.8 to 5.2 microns	Measures glass surface temperature in such operations as forming, bending, tempering annealing, and sealing. Also suitable for infrared heating.
48	0 to 600°F 500 to 1500°F 500 to 2500°F 0 to 300°C 300 to 800°C 300 to 1300°C	7.5 to 8.5 microns	Measures refractory brick, painted surfaces, plastics glass and infrared heating of these products. Especially good for thin films of plastics, oils, paper, wood, and other organic material.

Section 1 – INTRODUCTION

1.4 OPTICAL RESOLUTION

The MODLINE 4 detector "sees" a certain area (spot on a target surface. The diameter of the spot is determined by the design on the optical system and by the distance to the ttarget.

Fig. 1.4 is a plot of spot sizes at every increment of distance from the front flange of the MODLINE 4. The three dimensional "Cone of Vision" defines the viewing area of the MODLINE 4 at any given distance. Anything inside the cone is in the field of view and anything outside of the field of view is not.

If unobstructed, the cone of vision would expand to infinity. But in practice, you aim it so it falls on a target at some finite distance. In Fig. 1.4 below, the cone of vision falls on the target at the separation distance (D). At this distance, the diameter of the cone or viewing area on the target surface will have a spot size (d).

Note that if you move the MODLINE 4 a little closer the target will intersect a smaller cross section of the cone and give you a smaller spot. Moving it further away will give you a larger spot.

Spot size/separation distance relationships for the MODLINE 4 are give in the Model Indentification table (see section 1.5). This relationship defines the optical resolution or the smallest target the instrument can measure at any given distance. If the spot is larger than the target, the output current will be influenced partly by the target temperature and partly by the background temperature, and the instrument will give a false temperature reading.

The importance of resolving the target will be emphasized in the installation procedures.

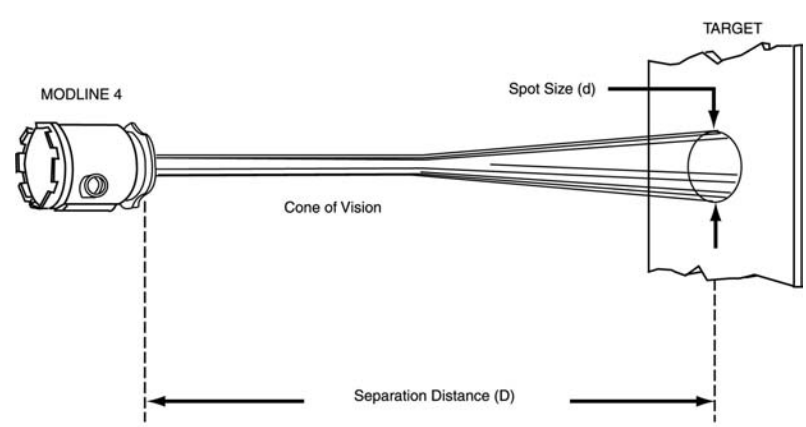


FIG. 1.4 SPOT SIZE vs. SEPARATION DISTANCE RELATIONSHIP

MODEL NUMBER

A		B			C	D	E
☐	☐ –	☐	☐	☐ –	☐ –	☐ –	☐
Series		Temp. Range			Opt. Res.	Output	Enclosure

BLOCK A Series Designation

Seven standard series are identified by this two-digit block. See Table 1.1 for characteristics of each series.

2 2	= 22 Series (8 to 14 µm)
4 3	= 43 Series (3.43 ±0.07 µm)
4 4	= 44 Series (8 to 14 µm)
4 5	= 45 Series (3.7 to 4.0 µm)
4 6	= 46 Series (2.0 to 2.6 µm)
4 7	= 47 Series (4.8 to 5.2 µm)
4 8	= 48 Series (7.5 to 8.5 µm)

BLOCK B Temperature Range

Standard temperature ranges available in each MODLINE 4 Series are listed below:

43 SERIES

0 4 F	= 120 to 400°F*
0 6 F	= 200 to 600°F
1 0 F	= 300 to 1000°F
0 2 C	= 50 to 200°C*
0 4 C	= 100 to 400°C
0 5 C	= 150 to 500°C

**Restrictions:*
Case operating temperature range 50 to 113°F (10 to 45°C);
Sudden ambient temperature change (up or down) of 10°C (18°F) will cause noticeable errors until the instrument temperature stabilizes.
Minimum response time setting 10 seconds for target temperatures from 120 to 300°F (50 to 150°C);
Minimum emissivity setting 0.5.

BLOCK B Temperature Range

(continued)

22 or 44 SERIES

0 2 F	= 0 to 200°F
0 5 F	= 0 to 500°F
1 0 F	= 0 to 1000°F
0 1 C	= 0 to 100°C
0 2 C	= 0 to 250°C
0 6 C	= 0 to 600°C

45 SERIES

1 5 F	= 500 to 1500°F
2 5 F	= 500 to 2500°F
0 8 C	= 300 to 800°C
1 3 C	= 300 to 1300°C

46 SERIES

1 0 F	= 500 to 1000°F
1 4 F	= 600 to 1400°F
0 6 C	= 250 to 600°C
0 8 C	= 350 to 800°C

47 SERIES

1 0 F	= 200 to 1000°F
1 5 F	= 500 to 1500°F
2 5 F	= 500 to 2500°F
0 6 C	= 100 to 600°C
0 8 C	= 300 to 800°C
1 3 C	= 300 to 1300°C

48 SERIES

0 6 F	= 0 to 600°F**
1 5 F	= 500 to 1500°F
2 5 F	= 500 to 2500°F
0 3 C	= 0 to 300°C**
0 8 C	= 300 to 800°C
1 3 C	= 300 to 1300°C

***High Resolution versions may require higher response time settings.*

BLOCK C Optical Resolution

Optical Resolution relates to the circular area viewed (Spot Size) at any given distance from the front of the MODLINE 4. See diagram and data below.

0	= Standard Resolution
1	= High Resolution
2	= Very High Resolution

BLOCK D Output

Standard Modline 4 output is 4-20mA, linear, corresponding to the temperature range. Peak Picker is optional (standard with Series 22).

0	= 4 to 20 mA
1	= 4 to 20 mA with Peak Picker

BLOCK E Enclosure

Standard Enclosure is an aluminum casting with NEMA 4 rating (Series 43 through 48).

Water-cooled Enclosure has a built-in air purge.

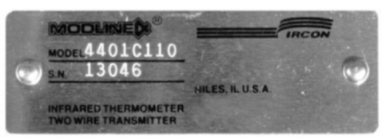
0	= Standard Enclosure
1	= Water-cooled Enclosure

Please note: A "*9*" in any block means the instrument has been specially modified. Refer to Section 1.7 for details of the modification.

Section 1 – INTRODUCTION

1.5 MODEL IDENTIFICATION

Note the model and serial numbers on the side plate of the sensor. Unscrew the back cover to make sure the model and serial numbers on the identification plate match those on the packing slip and on the side plate. The model number digit is explained below.



MODEL NUMBER PLATE

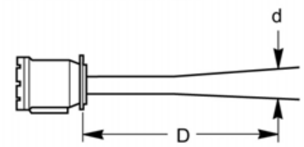
<u>Example:</u> ***Model 44-01C-1-1-0***

This model number designates a series 44 instrument with a temperature range of 0 to 100°C and high optical resolution. Output is 4 to 20 mA (peak picker included) and the instrument has a standard enclosure.

SPOT SIZE VS. SEPARATION

Reference Diagram
(not to scale)

d = Spot Size
D = Separation Distance



For Sensors with water-cooled castings, multiply spot size (d) from table or formula by 1.1 <u>Example:</u> If d is 8.2 inches per table or diagram, then d for water-cooled casting is: d = 8.2 x 1.1 = 9.02 inches

STANDARD RESOLUTION

D inches	d inches	D mm	d mm
0 to 15	1.0	0 to 380	25
20	1.7	500	41
30	3.0	700	67
50	5.6	1000	106
70	8.2	1500	171
100	12	2000	236
150	13	3000	366
200	25	5000	626
300	38	7000	886
500	64	10000	1280
700	90	15000	1930
1000	123	20000	2580

Formula

If D > 15 inches or 380 mm

$d_{inches} = 0.13 (D_{inches} – 15) + 1.0$

$d_{mm} = 0.13 (D_{mm} – 380) + 25$

Example: If D > 45 inches,
d = 0.13 (45 – 15) + 1.0
= 0.13 (30) + 1.0 = 3.9 + 1.0
= 4.9 inches
= 5 inches

<u>Models 43-04F and 43-02C only:</u>

$d_{inches} = 0.17 (D_{inches}) + 1.0$

$d_{inches} = 0.17 (D_{mm}) + 25$

HIGH RESOLUTION

D inches	d inches	D mm	d mm
0	1.00	0	25
15	1.25	300	30
30	1.5	700	37
60	2.0	1000	42
70	2.5	1500	50
100	4.0	2000	75
150	6.5	3000	125
200	9	5000	225
300	14	7000	325
500	24	10000	475
700	34	15000	725
1000	49	20000	975

Formula

If D > 60 inches or 1500 mm

$d_{inches} = 0.05 (D_{inches} – 60) + 2.0$

$d_{mm} = 0.05 (D_{mm} – 1500) + 50$

If D = 60 inches or 1500 mm

$d_{inches} = 0.017 (D_{inches}) + 1.0$

$d_{mm} = 0.017 (D_{mm}) + 25$

<u>Example:</u> If D > 90 inches,
d = 0.05 (90 – 60) + 2.0
= 0.05 (30) + 2.0 = 1.5 + 2.0
= 3.5 inches

VERY HIGH RESOLUTION

D inches	d inches	D mm	d mm
8	0.3	203	7.6
15	1	381	25.4
25	2	635	50.8
35	3	889	76.2
45	4	1143	101.6

Formula

If D > 8 inches or 203 mm

$d_{inches} = 0.1 (D – 8) + 0.3$

$d_{mm} = 0.1 (D – 203) + 8$

PLEASE NOTE;

Series 43 available with “Standard Resolution” only.
Series 22 not available with “Very High Resolution.”

1.6 SPECIFICATIONS

The following specifications are common to all Series of MODLINE 4:

Operating Wavelength Region:	Varies by Series (see Table 1.1)
Emissivity Range:	Adjustable from 0.10 to 0.99 in 0.01 increments
Power Supply and Load Requirements:	Input voltage: 24V direct current (dc) nominal16V direct current (dc) minimum to 40V direct current (dc) 20mA maximum. In order for the MODLINE 4 to meet European Electromagnetic Compatibility Directive, a CE version power supply is required. Load resistance: ≤1 ohm at 16 to 24V direct current; 1200 ohms at 40 V direct current (see Section 2.4 for additional information)
Fuse Rating:	For customer supplied power supplies, the power supply must be fused such that at 40V direct current the current (I) level must be less than 4 amps. At 16V direct current the current (I) cannot exceed 8 amps and the power supply total output must not exceed 150 VA.
Output Current:	4 to 20 mA direct current
Response Time: *(to 95% of any change in input)*	Continuously adjustable from approximately 0.15 sec to 10 sec
Peak Picker Decay Range: *(for models with Peak Picker)*	Continuously adjustable from approximately 15 sec to 30 min for full-scale decay
Humidity Limits:	0 to 90% non-condensing
Enclosure Material:	Aluminum
Weight:	Standard Enclosure: 2.6 lbs (1.2 kg) Water-cooled Enclosure: 20 lbs (9.25 kg)

The following specifications differ for Series 22 as compared to Series 43 through 48:

	Series 43 through 48	Series 22
Calibration Accuracy:	Within 0.75% of full-scale temperature or 3°F (1.7°C), whichever is greater	Within 1.0% of full-scale temperature or 5°F (2.8°C), whichever is greater
Repeatability:	0.3% of full-scale temperature	0.5% of full-scale temperature
Temperature Coefficient:	≤0.015%* of span per °F change from nominal value of 77°F over range of 32 to 150°F ≤0.027%* of span per °C change from nominal value of 25°C over range of 0 to 66°C	≤0.020% of span per °F change from nominal value of 77°F over range of 32 to 130°F ≤0.035% of span per °C change from nominal value of 25°C over range of 0 to 54°C
Case Operating Temperature Range:	Standard enclosure: 32 to 150°F (0 to 66°C) *(see previous page for exceptions)* Water-cooled enclosure: 32 to 400°F (0 to 204°C)	Standard enclosure: 32 to 130°F (0 to 54°C) Water-cooled enclosure: 32 to 400°F (0 to 204°C)
Environmental Rating:	NEMA 4	NEMA 4
Optical Centering:	Optical axis within 1° of mechanical center axis (within 0.2 in. per foot or 17 mm per meter separation distance)	Optical axis within 2° of mechanical center axis (within 0.4 in. per foot or 33 mm per meter separation distance)

*For Series 43-04F: ≤ 0.05% per °F
For Series 43-02C: ≤ 0.09% per °C

1.7 PRODUCT MODIFICATIONS

There are no special modifications in this instrument. It is standard in all respects.

Section 2 – INSTALLATION

2.1 INTRODUCTION

MODLINE 4 gives you the capability of building a custom-made temperature monitoring system for your process, If you follow the simple guidelines described in this section, you system will give accurate, trouble free service.

The MODLINE 4 is compatible with most 4 to 20 mA devices used in industry today. You can select a variety of indicators, recorders and other devices to complete your system. Combine these devices in series if you like or combine groups of MODLINE 4's and switch them manually or automatically to monitor key checkpoints in the process. As long as your system stays within the MODLINE 4 specifications, you will get good results. Most of the descriptions are based on the use of optional IRCON components. However, the descriptions also apply to any other devices that are compatible with the MODLINE 4 system.

- Model PS4-24 Power Supply
- TV-VIEW-VAAC Digital Indicator Power Supply

2. 2 BASIC SYSTEM

Fig. 2.1 illustrates a simple system consisting of the MODLINE 4, a Digital Meter and a Power Supply. These components form a continuous current loop.

System power is provided by the Power Supply which provides a DC output typically between 16 and 40 V direct current. AC line voltage is used to operate to operate the supply.

Loop current is determined by the MODLINE 4 which is calibrated to provide a 4 to 20 mA output. this current flows through all series loop components. It varies with target temperature over the full temperature span of the instrument. For example, an instrument with a temperature span of 500 to 1500°F will have a 4 mA output when viewing a 500°F target. The output increases to 20 mA when viewing a 1500°F target. The output is a linear 16 mA span, from 4 to 20 mA, over the instrument temperature range as illustrated in the Fig. 2.1 curve.

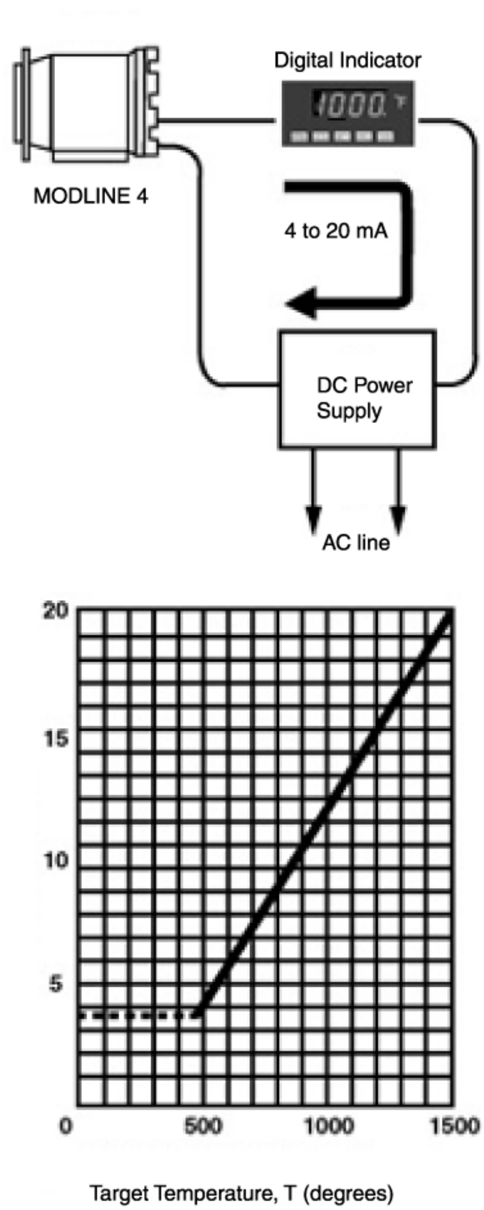


FIG. 2.1 BASIC MODLINE 4 CIRCUIT and RESPONSE CURVE

2.3 SUPPLY AND LOAD REQUIREMENTS

The MODLINE 4 operates at any supply voltage between 16 and 40 volts direct current. If you exceed the 40-volt upper i mit, you stand a chance of damaging the MODLINE 4 sensor. If you go below the 16-volt lower limit, the MODLINE 4 simply will not work.

If you furnish you own components, make sure they meet MODLINE 4 requirements. For a power supply, important specifications to look for are supply voltage and current capacity. For indicators, recorders, and other load elements, pay strict attention to the load resistance and, of course, the zero scale and full scale currents.

Part of the power supply voltage is dropped across the load and is not available for the MODLINE 4. In figure 2.1, for example, suppose the analog indicator has a resistance of 7 ohms. At the full scale current of 0.02A, the voltage drop across the indicator will be:

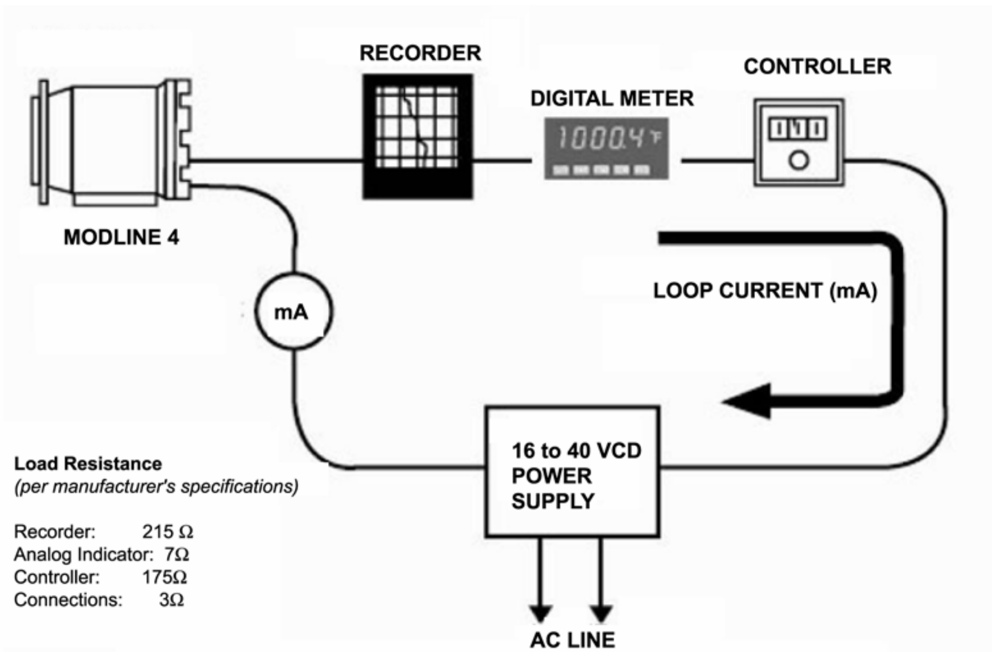
$$E = IE = 0.02 \times 7 = 0.14 \text{ V}$$

If the power supply voltage is 24 V, the MODLINE 4 operating voltage at maximum current will be 24 – 0.14 = 23.86 V, well above the required minimum of 16 V.

Table 2.1 shows how load voltage increases with load resistance. As load resistance increases, you need more DC supply voltage to cover the load voltage and still leave enough to operate the load voltage and still leave enough to operate the MODLINE 4.

Use Table 2.1 (see following page) as a guide in selecting your power supply. Be sure to total up all load resistance in your lood and add cable resistance if it will have a noticeable effect on loop resistance. If you plan to operate several indicators or other devices in the series, be sure to use toe TOTAL series resistance in your calculations (see figure 2.2 for an example).

NOTE: Connecting cable wires contribute a certain amount of resistance which adds to the load resistance. However, cable resistance per foot is usually small, and a cable run of 1500 feet will add no more than a few ohms to the circuit.



2.4 MULTIPLE LOAD SYSTEM

In Fig. 2.2, a recorder, analog indicator and controller are connected in a series in the loop. The 4 to 20 mA current determined by the MODLINE 4 flows through all of these load elements, producing voltage drops proportional to the resistance of each load element. The total load voltage is the sum of these voltage drops plus the drop across the connecting wires.

Assume the resistances are as indicated in Fig. 2.2:

This adds up to a total load resistance of:
$R_L = 215 + 7 + 175 + 3 = 400\ \Omega$

Total load voltage, $E_L = 1_{MAX}$ of 0.020A,
is: $E_L = 1_{MAX} \times R_L = 0.020 \times 400 = 8V$

With 8 V dropped across the load elements and cables, a supply voltage of at least 24 V is needed to ensure the required 16 V minimum for the MODLINE 4 (*see table 2.1 – Minimum DC Supply Requirements*).

TABLE 2.1
MINIMUM DC SUPPLY REQUIREMENTS
FOR MULTIPLE LOADS

Total Load Resistance (ohms)	Total Load Load (volts)	Minimum DC Supply (volts)
≥ 50	1	17
100	2	18
200	4	20
300	6	22
400	8	24
500	10	26
600	12	28
700	14	30
800	16	32
900	18	34
1000	20	36
1100	22	38
1200	24	40

<u>IMPORTANT</u>: DC supply voltage must never exceed 40 volts!

Section 2 - INSTALLATION

2.5 MULTIPLE LOOP SYSTEMS

Fig. 2.3 is an example of a multiple loop system. Two MODLINE 4 loops are operated from a single power supply. An arrangement of this type is suitable for measuring temperatures at two or more stations with an independent readout for each station. The advantage is the economy of a single power supply for all loops.

An important consideration in this system is the current capacity of the power supply. For example, if loops A and B in Fig. 2.3 are both measuring full scale temperature, currents 1A and 1B will be 20 mA for a total supply current of 40 mA.

The IRCON model PS4-24 power supply has a current capacity of 200 mA giving it the capability of powering up to ten MODLINE 4 loops.

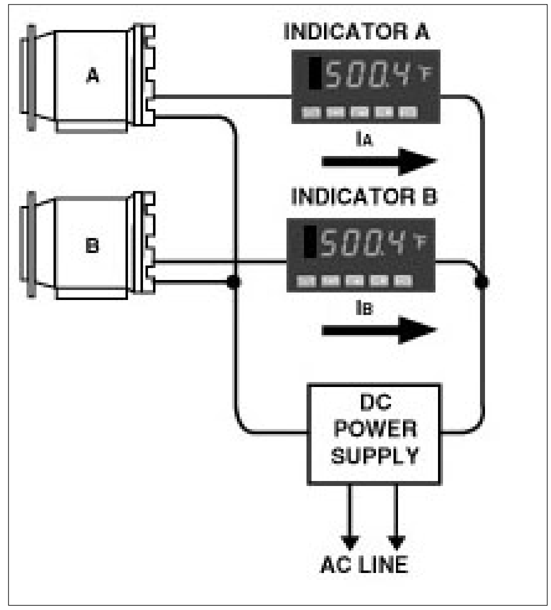


FIG. 2.3 MULTIPLE LOOPS OPERATED FROM SINGLE SUPPLY

2. 6 SWITCHED MODLINE 4 SYSTEM

Sometimes you can gain economy or efficiency by switching between circuit components. Fig 2.4 shows how this idea might be used to switch a single indicator and power supply to either of two MODLINE 4 units. This time-sharing system permits measuring the temperature at either of two stations on a single indicator.

The switching system shows consists of a double pole, double throw switch which allows simultaneous switching of both MODLINE 4 output leads. The switch can be a manual or an automatically controlled switch or a set of appropriate relay contacts.

NOTE: These illustrations give you an idea of how versatile MODLINE 4 can be in system design. Our systems give you just about any results you're looking for. If you need qualified help in choosing components or planning your system, contact IRCON Applications Engineering.
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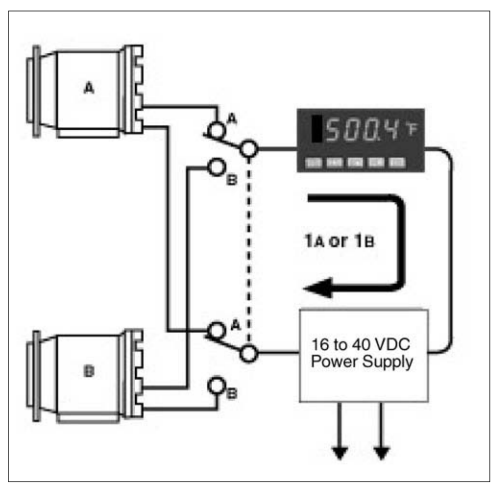


FIG. 2.4 SWITCHED MODLINE 4 UNITS

2.7 PRE-INSTALLATION NOTES

2.7a. General

The MODLINE 4 is a fixed focus instrument. The optical components are factory aligned to provide a fixed optical pattern which determines the size of measuring area, or what is called the "spot size" at any given distance from the front flange of the unit. This is the area the detector in the MODLINE 4 will "see" on the target surface.

Every step has been taken to ensure accurate measurements with excellent repeatability. the optical and electronic systems are factory calibrated against precision laboratory standards to initially set their accuracy specification.

If the MODLINE 4 is installed with reasonable care, it will provide accurate temperature measurements and a long, trouble-free operating life.

Modline 4 instruments are available in standard of water-cooled castings as shown in Fig. 2.5. The optical and electrical systems are essentially the same in both versions. Any differences that affect installation or operation will be pointed out in the following instructions.

! CAUTION !

Risk of Personal Injury

When this instrument is being used in a critical process that could cause property damage and personal injury, **The user should provide a redundant device or system that will initiate a safe process shutdown in the event that this instrument should fail.** The user should follow NEMA safety guidelines in the appendix.

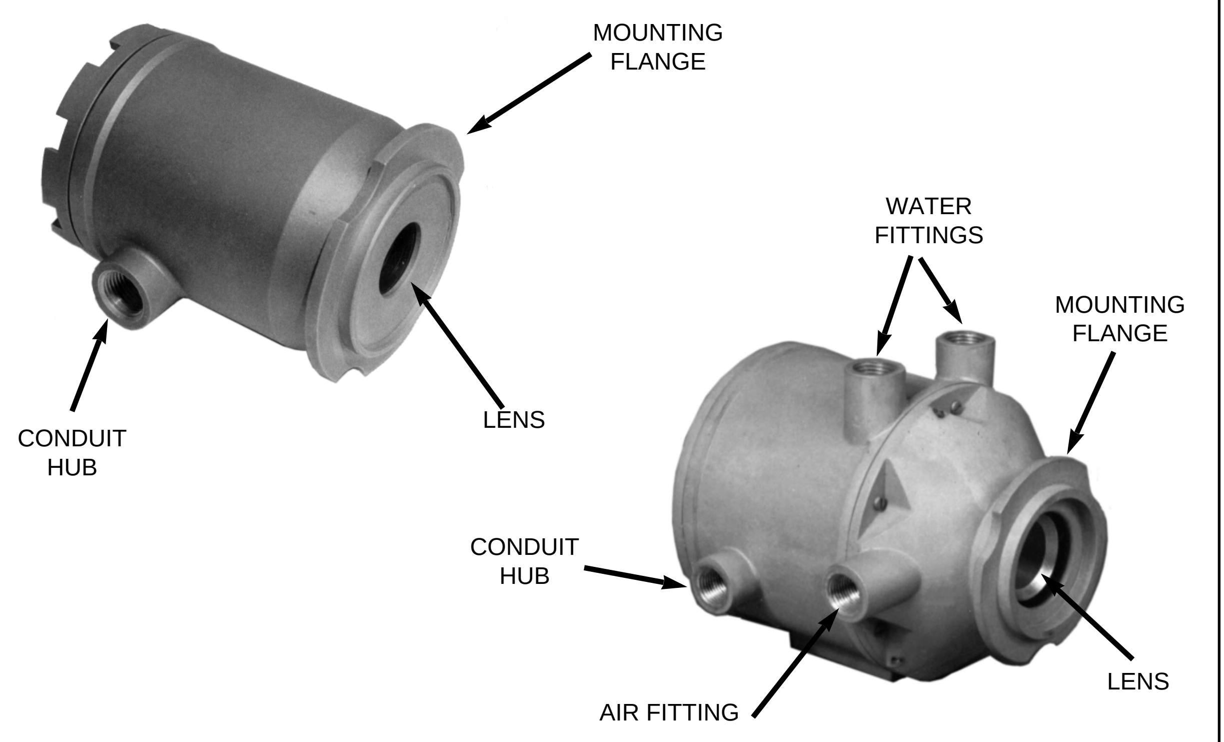


FIG. 2.5 – MODLINE 4 STANDARD AND WATER-COOLED CASTINGS

2. 7b. Mechanical Mounting

The MODLINE 4 may be mounted either by the front flange or by the mounting pad at the bottom of the casting. Mounting accessories are available as described in Section 5.

Procedures for aligning the unit on target are provided in Section 2.10.

If the proposed mounting surface is at earth ground potential, you can mount the Sensor directly to this surface with the bolts supplied. If the surface is not at earth ground potential, insulate the Sensor casting from the surface by inserting an insulating gasket and using insulating mounting hardware. See Section 2.15 for grounding details.

NOTE: Maximum Signal Cable length is 3000 ft (1000 m). Plan your mounting location and cable route accordingly.

2.7c. Ambient Temperature

STANDARD CASTING

The MODLINE 4 with a standard casting has an operating case temperature range of 32 to 150°F (0 to 66°C).* If you allow the temperature to go beyond these limits, incorrect temperature indications or damage to the instrument may result.

If you think the case temperature will approach the upper temperature limit due to ambient conditions, consider some type of auxiliary cooling. An IRCON Model WA-3 Water Cooling Accessory is one solution. (See Section 5 for details on this and other accessories.)

A heat shield between instrument and target as shown in Fig. 2.7 is another possible solution to excessive ambient temperatures. Air cooling by means of a blower fan or IRCON AA-3 Air Purge is another option. Call IRCON for other suggestions.

If the MODLINE 4 is to be located in the cold environments where its temperature may go below the lower temperature limit, consider some form of heating. For example, install the instrument in a temperature controlled enclosure or wrap it with electrical heater tape.

**Operating case temperature range for Series 43-04F and 43-02C are 50 to 113°F and 10 to 45°C, respectively.*

Operating case temperature range for all Series 22 is 30 to 130°F (0 to 54°C).

WATER-COOLED CASTING

A MODLINE 4 with a water-cooled casting can operate in ambient temperatures up to 400°F (200°C) with a minimum water flow rate of 20 gal./hr (75 liter/hr) of tap water at less than 75°F (24°C).

CABLE TEMPERATURE LIMITS

Maximum temperature rating of the Signal Cable is 220° F (100°C) for standard PVC-covered cable or 400°F (200°C) for IRCON-supplied silicone rubber-covered cable. Plan the cable routing accordingly.

2.7d. Air Purge

If dust, oil, vapors, etc. collect on the lens, low temperature indications will result. For instruments with standard castings, use an IRCON Model AA-3.

Air Purge to avoid the problem; a MODLINE 4 with water-cooled casting has an integral air purge.

NOTE: For Series 43-04F or 43-02C do not use a Model AA-3 Air Purge with a Model WA-3 Water Cooling accessory. With these two accessories combined, the front edge of the AA-3 will obstruct the Cone of Vision and cause errors in the temperature readings.

A supply of clean, dry instrument air or filtered dry plant air at a flow rate of 6 ft ^{3}/min (0.17 m ^{3}/min) is recommended.

NOTICE
All MODLINE 4 Series instruments use multilayer coatings on their lenses to define their spectral properties and to increase optical transmission. Although these coatings satisfy military specifications for durability, all coated lenses are susceptible to damage from harsh environments. Whenever moisture, oils, or active chemicals condense on a coated lens, the optics become stained. The stains are difficult to clean and tend to break down the coating. Use of an air purge will help prevent condensation and damage in harsh environments, but only the purge is supplied with clean air. If necessary, install air filters in the air path.

2.7e. Spot Size and Resolution

Observe the guidelines in Section 2.9 regarding spot size and resolution. Above all, make sure the target surface is at least twice the spot size (or the spot size *is less than half the target size*) at the viewing distance.

2.7f. Intervening Objects

Errors can be caused by objects between the MODLINE 4 and target. Any such object that happens to be inside the Cone of Vision will be visible to the detector, and will cause an error in the temperature reading.

Before selecting the mounting location, consider the sight path just as you do when you aim a camera to take a photograph. Try to picture the Cone of Vision, is within the cone, select a different viewing angle.

2.7g. Reflections

Reflections from other radiating objects represent a potential source of error in your temperature readings. The total radiation seen by the MODLINE 4 will be a combination of intrinsic radiation plus reflected radiation.

Examples of interfering sources are hot furnace walls and heating elements that are hotter than the target object.

Most reflection problems can be eliminated by changing the viewing angle or shielding the reflections. Suggestions for anticipating and eliminating common reflection problems are provided in Section 6. However, if you are faced with unusual reflection problems, call IRCON Technical Service for recommendations.

2,7h. Use of Windows

If it is necessary to view the object through a window, as is the case when the object is being heated in a vacuum or inert atmosphere, be careful in selecting the window material. The material must have good transmission characteristics in the wavelength band of the MODLINE 4 series.

A guide to appropriate windows for all MODLINE 4 Series is provided in Section 3.4.

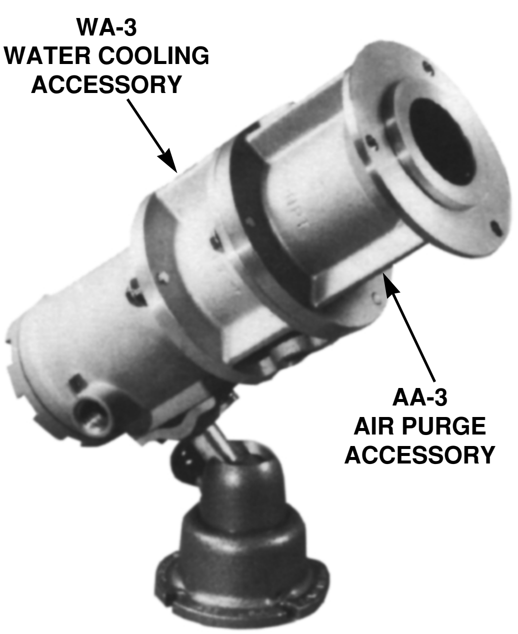
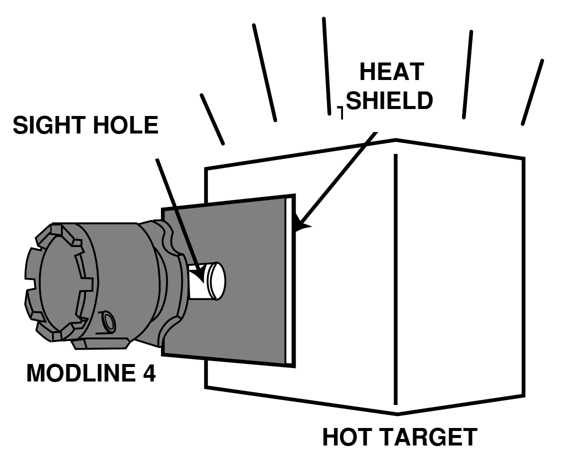


FIG. 2.6 – MODLINE 4 (STANDARD ENCLOSURE) WITH AIR PURGE and WATER COOLING SYSTEM



NOTE: Sight hole must be large enough so heat shield does not obstruct sight path. (See Sections 2.9 and 2.10). Also, MODLINE 4 must not contact heat shield.

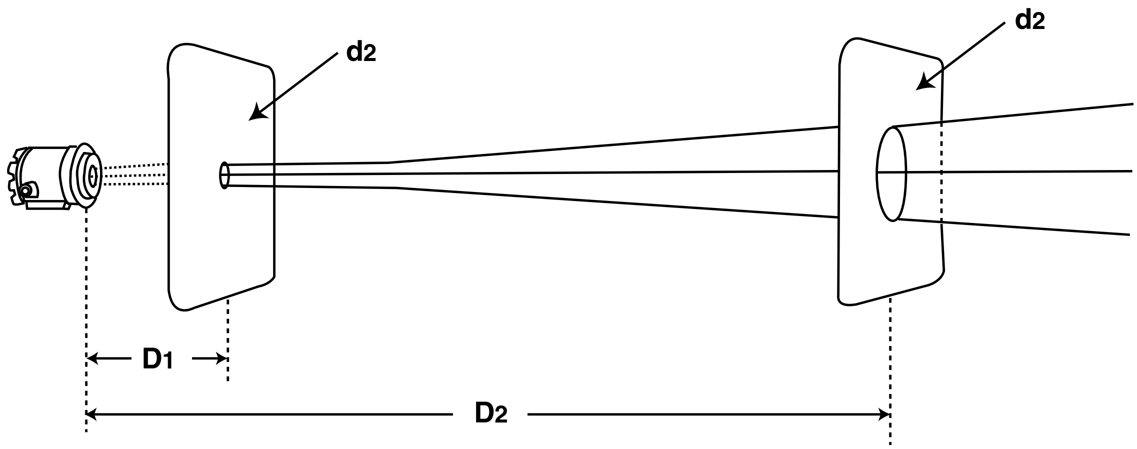
FIG. 2.7 – MODLINE 4 (STANARD ENCLOSURE) PROTECTED BY HEAT SHIELD

Section 2 — INSTALLATION

2.8 OPTICAL CHARACTERISTICS

The detector responds to infrared radiation in a area indicated by the CONE OF VISION in Fig. 2.8. It will measure temperature of objects inside this cone. It will not measure objects outside the cone.

The spot size (d) is the diameter of the cone at a particular separation distance (D). Separation distance is the distance between the front of the sensor and the target object whose temperature is being measured. In Fig. 2.8, d_1 and d_2 represent the spot size at two different distances D_1 and D_2.



NOTE: See Table 2.2 for details on finding Spot Size at any given SEPARATION Distance.

FIG. 2.8 – SPOT SIZE VS. SEPARATION DISTANCE

Correct temperature measurement requires that the field of view be filled entirely by the target. Fig. 2.9 illustrates this ideal condition. Good practice is to make sure that the target surface is at least twice the spot size at the spacing used. This gives you a "cushion" for shifts in MODLINE 4 or target position, and for the small tolerances in true vs. design diameter of the Cone of Vision that are inherent in all optical pyrometers.

If the target is not larger than the spot size, the detector will see infrared radiation from other objects in its field of view as well as the target. This causes incorrect temperature indications.

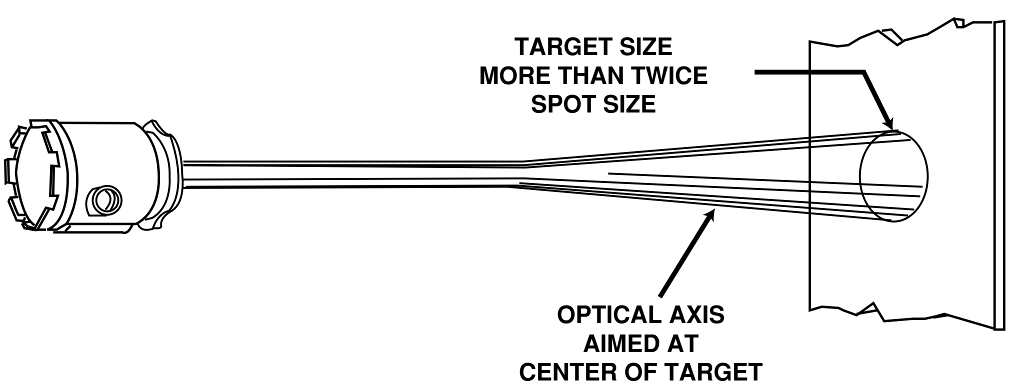
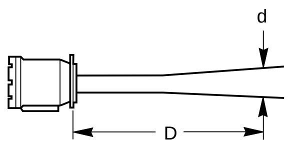


FIG. 2.9 – IDEAL RESOLUTION AND AIMING PROVIDE MAXIMUM MEASUREMENT ACCURACY

TABLE 2.2 – SPOT SIZE VS. SEPARATION DISTANCE

Reference Diagram
(not to scale)

d = Spot Size
D = Separation Distance



For Sensors with water-cooled castings, multiply spot size (d) from table or formula by 1.1
Example: If d is 8.2 inches per table or diagram, then d for water-cooled casting is:
d = 8.2 x 1.1 = 9.02 inches

STANDARD RESOLUTION

D inches	d inches	D mm	d mm
0 to 15	1.0	0 to 380	25
20	1.7	500	41
30	3.0	700	67
50	5.6	1000	106
70	8.2	1500	171
100	12	2000	236
150	13	3000	366
200	25	5000	626
300	38	7000	886
500	64	10000	1280
700	90	15000	1930
1000	123	20000	2580

Formula
If D > 15 inches or 380 mm
$d_{inches} = 0.13\ (D_{inches} - 15) + 1.0$
$d_{mm} = 0.13\ (D_{mm} - 380) + 25$

Example:
If D = 45 inches,
d = 0.13 (45 – 15) + 1.0
= 0.13 (30) + 1.0 = 3.9 + 1.0
= 4.9 inches
= 5 inches

For Models 43-04F and 43-02C only:
$d_{inches} = 0.17\ (D_{inches}) + 1.0$
$d_{inches} = 0.17\ (D_{mm}) + 25$

HIGH RESOLUTION

D inches	d inches	D mm	d mm
0	1.00	0	25
15	1.25	300	30
30	1.5	700	37
60	2.0	1000	42
70	2.5	1500	50
100	4.0	2000	75
150	6.5	3000	125
200	9	5000	225
300	14	7000	325
500	24	10000	475
700	34	15000	725
1000	49	20000	975

Formula
If D > 60 inches or 1500 mm
$d_{inches} = 0.05\ (D_{inches} - 60) + 2.0$
$d_{mm} = 0.05\ (D_{mm} - 1500) + 50$

If D < 60 inches or 1500 mm
$d_{inches} = 0.017\ (D_{inches}) + 1.0$
$d_{mm} = 0.017\ (D_{mm}) + 25$

Example:
If D = 90 inches,
d = 0.05 (90 – 60) + 2.0
= 0.05 (30) + 2.0 = 1.5 + 2.0
= 3.5 inches

VERY HIGH RESOLUTION

D inches	d inches	D mm	d mm
8	0.3	203	7.6
15	1	381	25.4
25	2	635	50.8
35	3	889	76.2
45	4	1143	101.6

Formula
If D > 8 inches or 203 mm
$d_{inches} = 0.1\ (D - 8) + 0.3$
$d_{mm} = 0.1\ (D - 203) + 8$

Notes: 1. Series 22 not available with very high resolution.
2. Series 43 available only with standard resolution.

Spot Size/Separation Distance relationships are given in Table 2.2. As shown in the table, MODLINE 4 models are available with Standard Resolution, High Resolution and Very High Resolution.

NOTE: Series 22 instruments are not available with Very High Resolution; Series 43 instruments are available only with Standard Resolution.

The Resolution is designated by model number Block C labeled on the back of the identification plate on the side of a standard casting.

A *0* designates *Standard* Resolution; a *1* designates *High* Resolution; and a *2* designates *Very High* Resolution.

Determine the Resolution rating (Standard, High or Very High Resolution) of your instrument, then refer to Table 2.2 for details on the optical characteristics.

2.9 ALIGNING THE MOUNTING AXIS

A MODLINE 4 is "sighted" on the target object by aligning its mechanical axis so that its mechanical centerline intersects the target at the center of the desired viewing area. The optical axis is aligned very closely with the mechanical axis. Thus, by aligning the mechanical axis you are also aligning the Cone of Vision so it is centered on the desired viewing area.

Where very large target surfaces are involved (target size many times larger than spot size), alignment can be as simple as sighting along the top or side of the casting and aiming it so it points roughly at the center of the target. For more accurate alignment, refer to the following instructions.

BASE MOUNTING

If you plan to mount the MODLINE 4 by its base pad, project a straight line from the bottom surface of the base pad to a point below the center of the desired point of measurement on the target as shown in Fig. 2.10. For a standard casting this point should be 2.1 in. (53 mm) below the center of the measurement point. For a water-cooled casting it will be 3.3 in. (84 mm) below the center of the measurement point. This establishes your vertical alignment.

Align the mounting hole positions on the mounting support 50 they form a straight line aimed at the center of the desired measuring point on the target surface. This establishes your horizontal alignment.

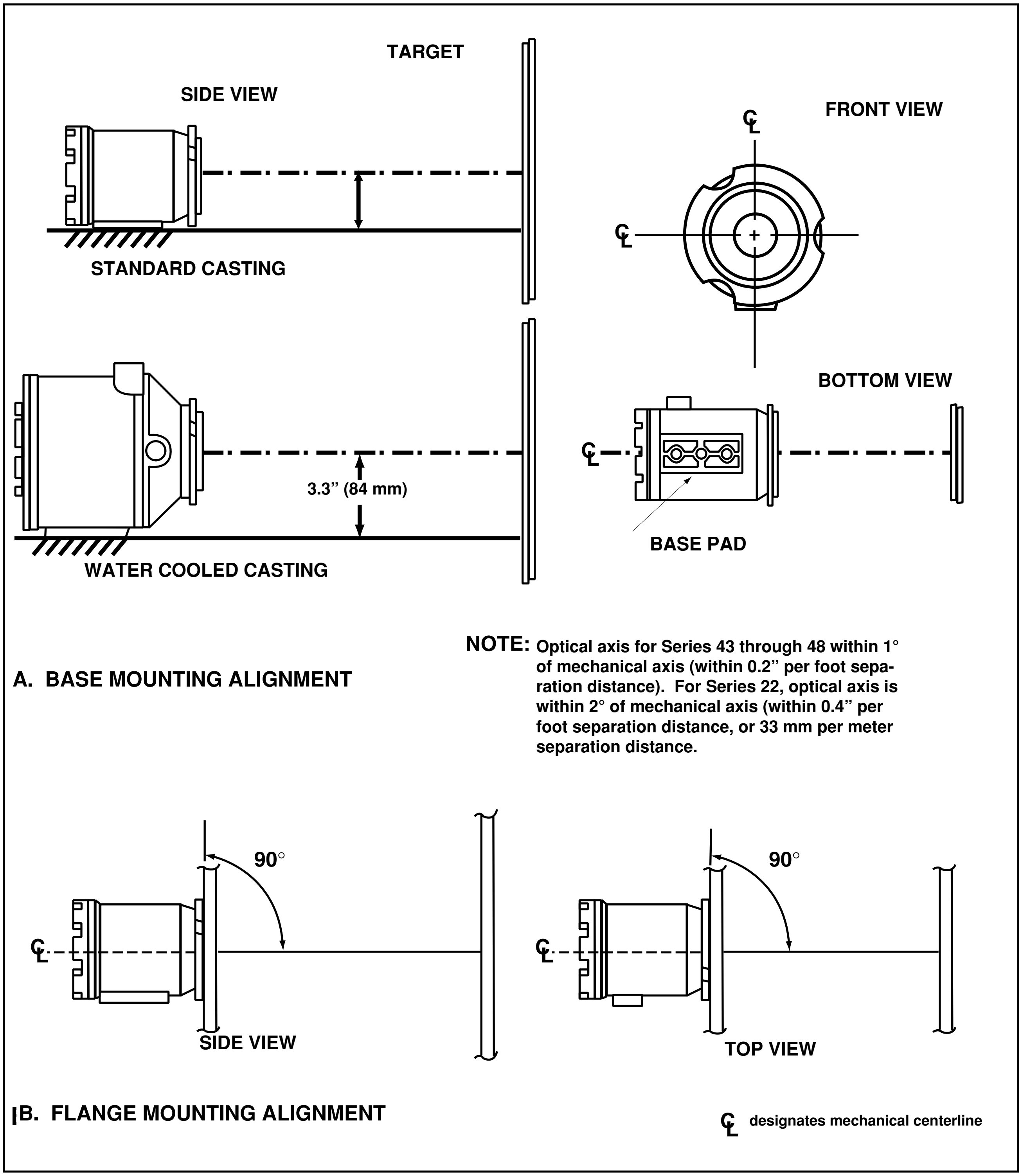
Note that these alignment axes and prepare the mounting support. When the base pad is bolted to the mounting support, the optical axis will be centered on the desired viewing area.

FRONT FLANGE MOUNTING

The second mounting method is to use the front flange of the MODLINE 4 as the mounting surface. The instrument's optical axis, which is coincident with the mechanical centerline of its casting, is perpendicular to the front flange mounting surface. The instrument should be mounted such that the optical axis projects to intersect the target surface at the center of the desired viewing area.

This method requires that you visualize a straight line from the center of the lens to the desired center point on the target. This line is the optical axis. Erect a mounting support with surfaces perpendicular to this axis. When the front flange is placed against this mounting support, its line of sight will be properly aligned with the target.

NOTE: The diagram shows the MODLINE 4 front flange parallel to the target surface, and the optical axis exactly perpendicular to the surface. However, you can mount the MODLINE 4 so the optical axis is at some other angle to the target. In this case the "spot" will be elliptical rather than circular, but as long as the target surface is large enough to accommodate the widest axis of the spot, this will not present a problem.



NOTE: Optical axis for Series 43 through 48 within 1° of mechanical axis (within 0.2” per foot separation distance). For Series 22, optical axis is within 2° of mechanical axis (within 0.4” per foot separation distance, or 33 mm per meter separation distance.

FIG. 2.10 – DETERMINING ALIGNMENT OF MOUNTING AXIS

2.10 MOUNTING PROCEDURE
(Standard Casting)

These instructions apply to instruments with standard castings. Instructions for mounting water-cooled castings are provided in Section 2.12.

The MODLINE 4 is ordinarily mounted by the front circular flange or base mounting pad to a support which has been previously installed to provide the correct line of sight. Mounting dimensions are given in Fig. 2.11.

The instrument may be mounted in any orientation that will afford a clear, unobstructed line of sight and a reliable support.

BASE MOUNTING

If you are mounting the MODLINE 4 with no accessories, attach it to the fixture of your choice using three 1/4–20 NC bolts. Observe grounding precautions in Section 2.15.

In some cases freedom of final adjustment in sighting may be desirable. In these cases the Swivel Mounting Base, Model SB-1, is recommended as an optional accessory. See Section 5 for a description of this accessory.

If you are using accessories such as the Model WA-3 Water Cooling Accessory and/or Model AA-3 Air Purge, you can assemble the MODLINE 4 and accessories, then mount the complete assembly by means of the MODLINE 4 base pad. See Fig. 2.12 for an example of this arrangement.

FLANGE MOUNTING

The MODLINE 4 can be flange mounted to mounting supports or accessories by means of three 5/16–18NC bolts supplied. The flange cutouts and special bolts provide a 'quick disconnect" feature that makes it easy to remove the MODLINE 4 for lens cleaning and other service routines. The mounting procedure is illustrated in Fig. 2.13. Observe the grounding precautions in Section 2.15.

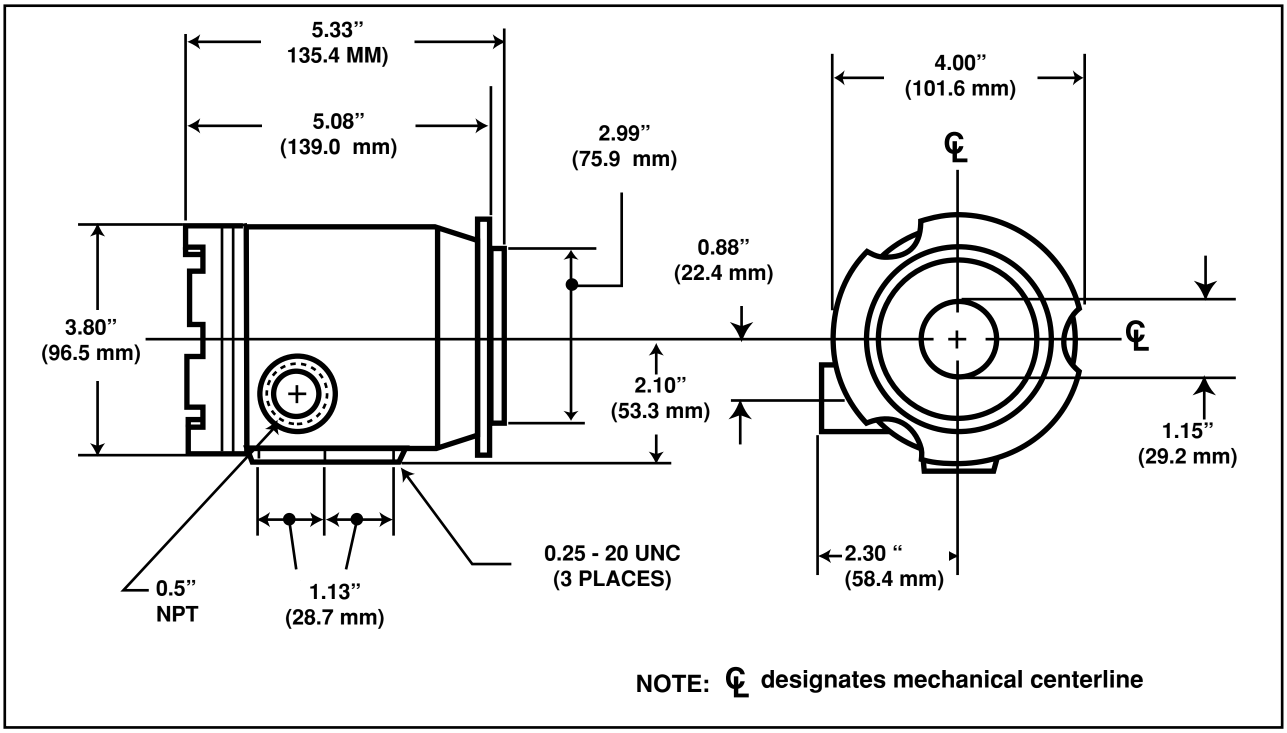


FIG. 2.11 – DIMENSIONS AND CLEARANCES OF STANDARD CASTING

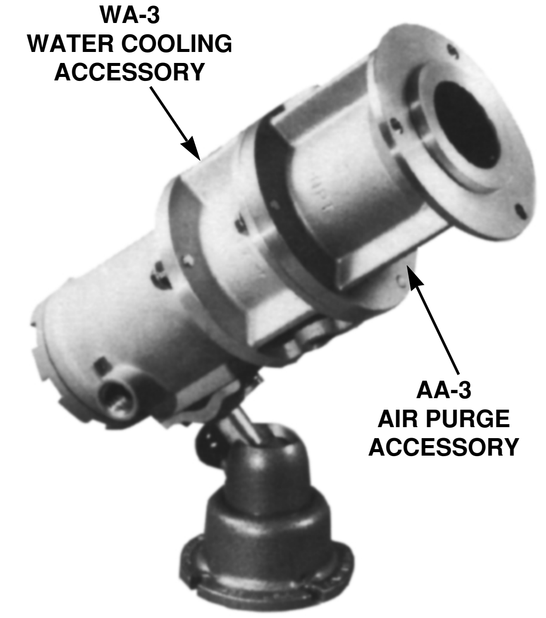


FIG 2.12 – MODLINE 4 (STANDARD CASTING) WITH AIR PURGE AND WATER COOLING ACCESSORIES

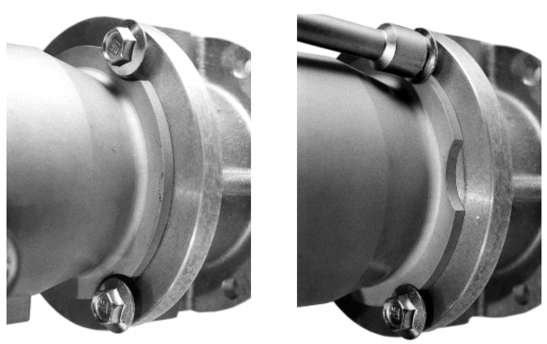


FIG. 2.13 – FLANGE MOUNTING PROCEDURE

Section 2 — INSTALLATION

2.11 MOUNTING PROCEDURE
(Water-Cooled Casting)

These instructions apply to instruments with water cooled castings. Instructions for mounting standard castings are provided in Section 2.11.

The MODLINE 4 is ordinarily mounted by the front circular flange or base mounting pad to fixed brackets which have been previously installed to provide the correct line of sight. Mounting dimensions are given in Fig. 2.14.

The instrument may be mounted in any orientation that will afford a clear, unobstructed line of sight and a reliable support, and also allow access to the water, air and cable fittings.

BASE MOUNTING

If you are mounting the MODLINE 4 with no accessories, attach it to the fixture of your choice using three 1/4–20 NC bolts. Observe grounding precautions in Section 2.15.

For freedom of final adjustment in sighting, the Swivel Mounting Base, Model SB-3, is recommended as an optional accessory. See Section 5 for a description of this accessory.

FLANGE MOUNTING

The MODLINE 4 can be flange mounted to mounting supports or accessories by means of three 5/16–18 NC bolts supplied. The flange cutouts and special bolts provide a "quick disconnect' feature that makes it easy to remove the MODLINE 4 for lens cleaning and other service routines. The mounting procedure is illustrated in Fig. 2.15. Observe the grounding precautions in Section 2.15.

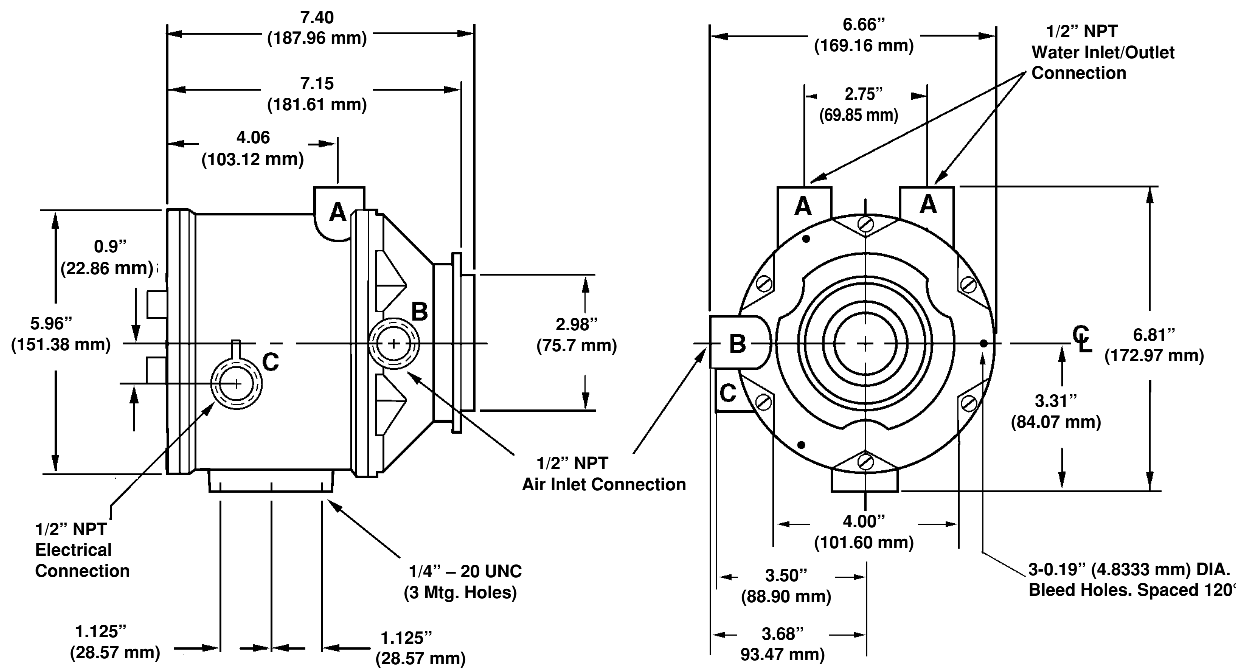


FIG. 2.14 – DIMENSIONS AND CLEARANCES OF WATER-COOLED CASTING

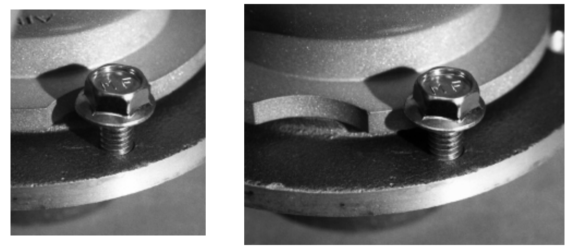
WATER AND AIR REQUIREMENTS

Route water and air lines before installing the MODLINE 4. Coolant water must flow to protect the Sensor from high ambient temperature whether the system is operating or not.

NOTICE

The chemical content of the coolant water must be compatible with Sil Brass (CDA 87500) of the casting to ensure normal operating life.

Fittings are provided for standard pipe threads or hose fittings as indicated in Fig. 2.16. Direction of water flow is not critical. However, if the MODLINE 4 is oriented so the water fittings are not level, attach the inlet line to the lower of the two fittings.



A. Place flange cutouts over 5/16–18 NC bolts installed in mount or accessory.

B. Rotate MODLINE 4 so bolts capture flange, and tighten bolts.

FIG. 2.15 – FLANGE MOUNTING PROCEDURE

COOLING WATER

Supply . . . . .Tap water (see Notice)
Flow rate . . . . .20 gal./hr (75 liters/hr)
Flow direction . . . . .Either
Temperature at inlet . . . .75°F (24°C) maximum*
Pressure inside enclosure . . . . .Must not exceed 75 psi (5.1 bar)

*Permits operation at ambient up to 400°F (200°C)

PURGING AIR

Supply . . . . .Clean, dry instrument air or filtered dry plant air
Flow rate . . . . .6 ft^3/min (0.17 m^3/min)
Flow direction . . . . .Either
Temperature at inlet . . . .50 to 100°F (16 to 31°C)

PRECAUTIONS

1. DO NOT loosen or remove screws holding front or rear bell to main casting. This would destroy factory seal, degrading performance and creating possible leakage problems.
2. In closed loop water systems, install relief valve with maximum pressure rating not to exceed 75 psi (5.1 bar) to prevent possible damage to MODLINE 4.

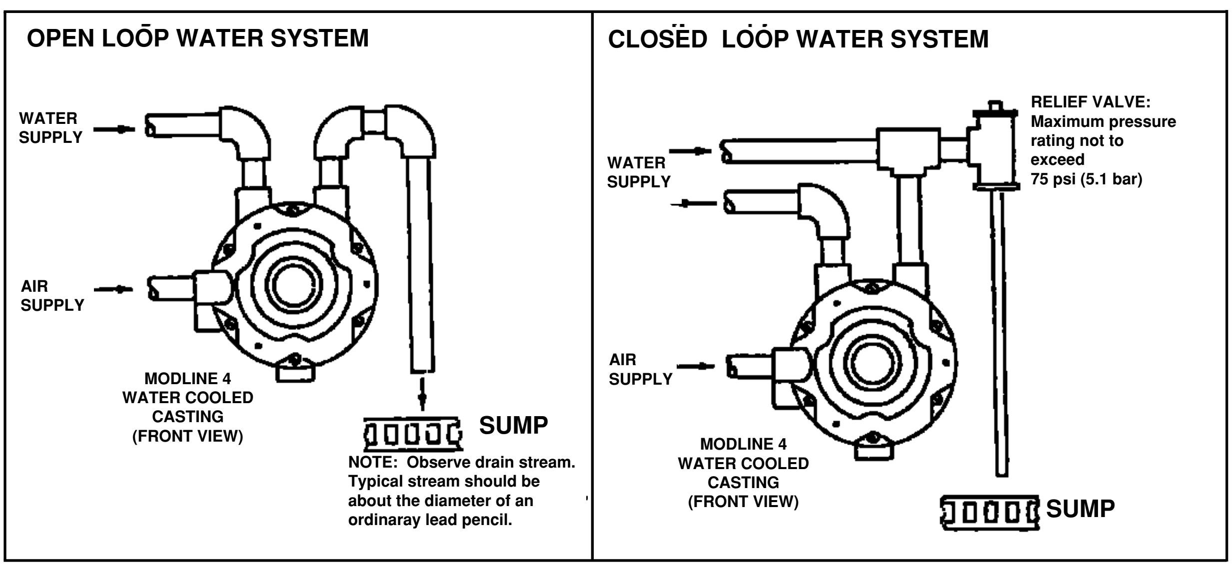


FIG. 2.16 – TYPICAL WATER AND AIR FLOW CONFIGURATIONS

2.12 SPECIAL MOUNTING SITUATIONS

Sometimes it is necessary to view a target through a sight hole, or through an aperture sealed by a window. There are also times when the physical restraints of the process environment make it difficult, if not impossible, to mount the MODLINE 4 for a convenient, head-on view of the target. These and other 'special situations" call for special mounting procedures.

Fig. 2.17 is an example of a MODLINE 4 sighted on a target through a sight hole cut for the purpose. A sight window is shown mounted on the sight hole.

Two special considerations immediately present themselves in this situation:

1. The sight hole diameter must be large enough to allow the instrument to view the target. Never obstruct any part of the Cone of Vision.

2. The window must be able to transmit the infrared energy. Consult Table 3.1 of Section 3 to determine the proper material for your MODLINE 4. If a window is used, it must be kept clean or low temperature indications will result.

Acute viewing angles can present problems of reduced emissivity values, particularly if you are dealing with smooth target surfaces.

Figure 2.18 shows the permissible angles when viewing smooth surfaced objects such as metals, glass or plastics. Angles of up to 45° from the perpendicular will not appreciably affect the measurement. Angles greater than 45° should be avoided. An increase in reflectance occurs when smooth surfaces are viewed at large angles, and consequently the target emissivity decreases.

These are just a couple of special situations and the things to watch for in dealing with them. If you run into these or other situations that may cause problems, consult IRCON Applications Engineering. Our many years of experience in facing and solving temperature measurement problems can be of great benefit!

NOTE: Section 6 offers some application guides that may be helpful.

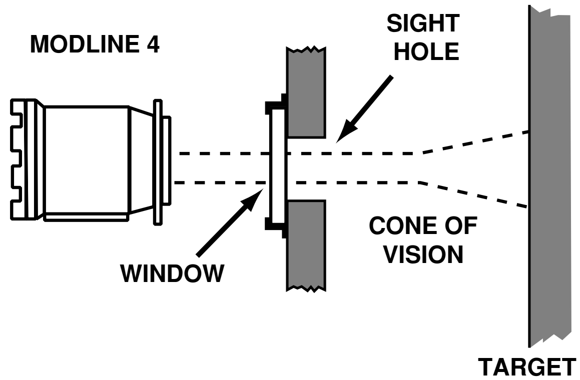


FIG. 2.17 – VIEWING TARGET THROUGH SIGHT HOLE AND WINDOW

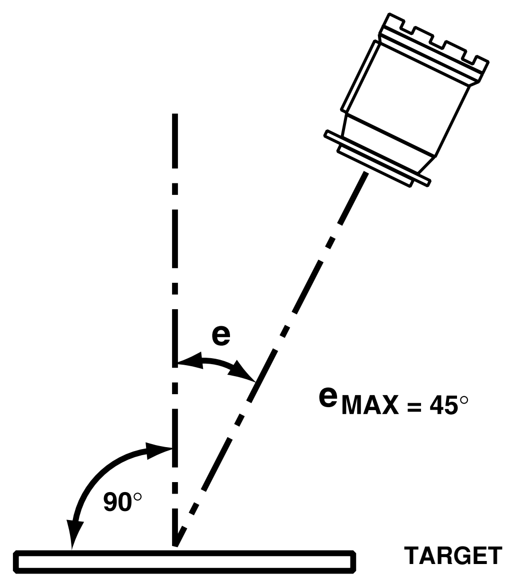


FIG. 2.18 – VIEWING ANGLE LIMITATIONS FOR SMOOTH TARGET SURFACES

2.13 CABLE SELECTION and MODLINE 4 WIRE TERMINATIONS

SPECIAL INSTRUCTIONS FOR EEC COMPLIANCE

In order for the MODLINE 4 to be immune to RF susceptibility, either all wiring to the sensing head must be run in conduit or a single overall shielded cable must be used. The shield must be 360°, terminated at the sensing head using the special cable shield grip adapter provided. To maintain electromagnetic immunity, only Indicators and Power Supplies that meet EMC Directive and carry the CE Mark can be used with the MODLINE 4.

SELECTING AND PLANNING CABLING

After you have mounted all system components, proceed with the electrical wiring. We recommend a three-conductor twisted cable with overall shield. The most practical wire sizes to use for the signal loop are 14- to 18-gauge.

If the instrument you have ordered has a peak picker and you plan to wire an external peak picker control switch, select a five-conductor twisted cable with overall shield to feed through the cord grip. A 18-gauge wire size is required to support an external peak picker.

The longest run of wiring will usually be from the MODLINE 4 to the Power Supply and Indicator. Cable lengths up to 3000 ft (1000 m) are acceptable for most installations. (This limit on cable length also applies to the peak picker wiring.) However, make sure the cable resistance at the length you plan to use between the MODLINE 4 and the power supply will not cause an excessive voltage drop. As an example, a 3000-foot length of 18-gauge cable may develop a voltage drop of 0.65 V when carrying 20 mA full-scale current. The power supply voltage must be sufficient to accommodate this voltage drop and still supply normal operating voltage for the MODLINE 4.

Keep the MODLINE 4 system wiring away from high power or r-f wiring and avoid hot areas that can damage the cable. If needed, high-temperature cables are available that can withstand 400°F (200°C).

INSTRUMENT AND WIRING ENCLOSURE

Cabling enters the MODLINE 4 through a conduit hub threaded for 0.5-inch conduit. The cord grip has a bushing (grommet) that accepts cable diameters from 0.225 to 0.350 in. (5.72 to 8.89 mm).

IMPORTANT: The cord grip assembly must be tightened sufficiently following wiring installation to provide the NEMA 4 rating of the MODLINE 4.

If you ordered your MODLINE 4 with the peak picker option and are installing an external switch, select a five-conductor twisted cable with overall shield to feed through the cord grip.

NOTE: If plant practices or electrical codes require the use of conduit, use the appropriate conduit fitting in place of the cord grip.

CAUTION

Risk of Personal Injury

In order for the MODLINE 4 to meet EMC Directive, the Indicators and Power Supplies must also meet the Directive and carry the CE Mark.

Section 2 — INSTALLATION

CABLE ROUTING FOR THE INSTRUMENT

Remove the back cover of the enclosure. Unscrew by hand, or if the cover is sealed tightly, use a rod or bar in the torquing slots (standard enclosure) or against the torquing studs (water-cooled enclosure).

Thread the cables through the cord grip grommet into the MODLINE 4 case. Figure 2.19 illustrates proper assembly of the cord grip, grommet, and cable. When assembling the parts of the cord grip, you will thread components onto the cabling in their specified order, which is as follows:

1. Hub cap and grommet
2. Compression spring
3. Connection housing
4. Conduit hub

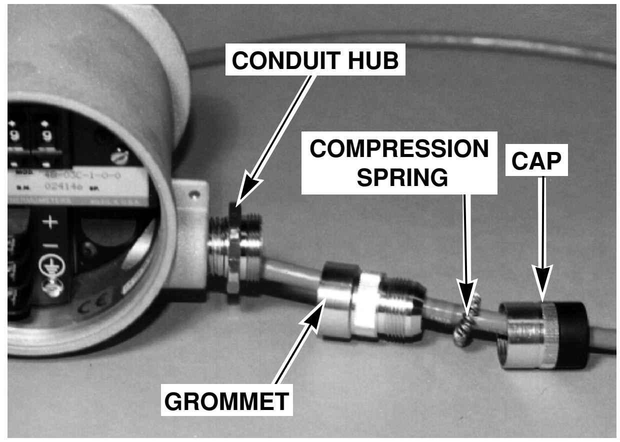


FIG. 2.19 – CORD GRIP WITH CABLING

Insert Wires

Prepare the series loop cable by stripping the two wires. Leave enough of the braided shield exposed so that the compression spring can make adequate contact. Attach the signal cable shield to earth ground at the power supply end. Insert the wires under the compression clamps on the terminal strip as shown in Fig. 2.20.

NOTE: For proper termination of your system (including systems with multiple device loads), refer to Section 2.15.

If you ordered your MODLINE 4 with a peak picker option, refer to Section 2.16.

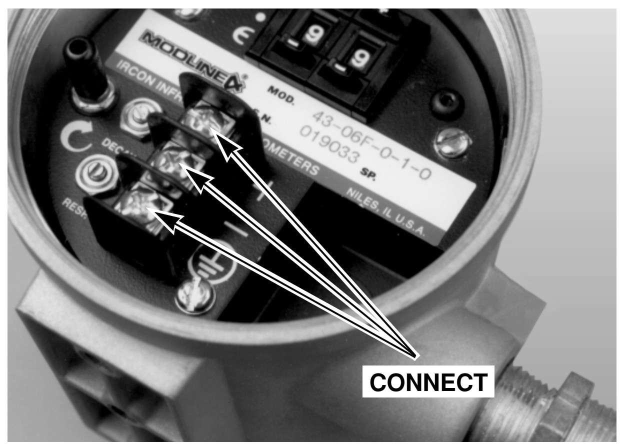


FIG. 2.20 – CONNECT THE SERIES LOOP WIRES TO THE MODLINE 4 TERMINAL STRIP: plus (+) and minus (-), and EARTH GROUND TERMINAL SCREWS.

2.14 SYSTEM WIRING AND GROUNDING

Wiring and recommended grounding for typical system loops in which the MODLINE 4 instrument is installed are shown in Figures 2.22, 2.23, 2.24, and 2.25. Always ensure proper polarity connections between components and follow the grounding recommendations described herein.

If the MODLINE 4 flange or base is attached to a surface that is not at the same earth ground potential as the opposite end of the cable where the shield is terminated to earth, provide isolation between the MODLINE 4 and the mounting surface. Insert a non-conductive gasket (customer supplied) between case and mounting surface, and use non-conductive mounting hardware to secure the assembly.

Regardless of which mounting method you use, connect the cable shield at the power supply end of the cable to ground.

Grounding the Loop

Ground the loop of devices in the system at only one point. Refer to Figures 2.22, 2.23, 2.24, and 2.25.

Grounding requires special care in a multiple load system like the system shown in Figure 2.24 as an example. Check the internal ground arrangement for the power supply and each load component (per manufacturer's instructions). Select one component that has an input terminal at ground potential, and use that one terminal as the loop ground point. If no component has an internal ground, connect one side of the power supply to ground.

AC Power

AC Line Power must be available to operate the Power Supply. Wiring, fusing, and switching of the Power Supply should conform to your plant practices and the National Electrical Code. A third wire power ground should be connected to the enclosure or panel. This ground can also be used for loop system grounding, if required.

CAUTION

SENSOR CASE MUST BE GROUNDED

Connect a ground wire from the Earth Ground Terminal Screw on the terminal strip to an earth ground at the power supply end.

The earth ground wire MUST be at least as large as the largest power conductor wire.

Failure to make this connection can cause a shock hazard and erratic operation or possible damage.

2.15 PEAK PICKER WIRING

If you ordered the peak picker option and you are planning to reset the peaked signal remotely, you will need to wire to the peak picker plug and a remote switch as it is shown in Fig. 2.25.

Customer-Supplied Items

Customer-supplied items needed to install the peak picker are listed below.

- Wire: 5-conductor cable with overall shield (conductor should be at 18–22-gauge)
- Switch (for remote reset): SPST
- Wire clipper and soldering iron

To Install

To wire the peak picker plug and remote switch, follow these steps:

1. Strip the two peak picker remote reset wires.
2. Thread the two wires through the plug cover.
3. Solder Wire 1 (see Fig. 2.25) to the center solder cup of the plug.
4. Solder Wire 2 (see Fig. 2.25) to the solder/crimp lug and crimp.
5. Screw down the plug cover over wires.
6. Connect the cable shield to an external Earth Ground at the switch end.

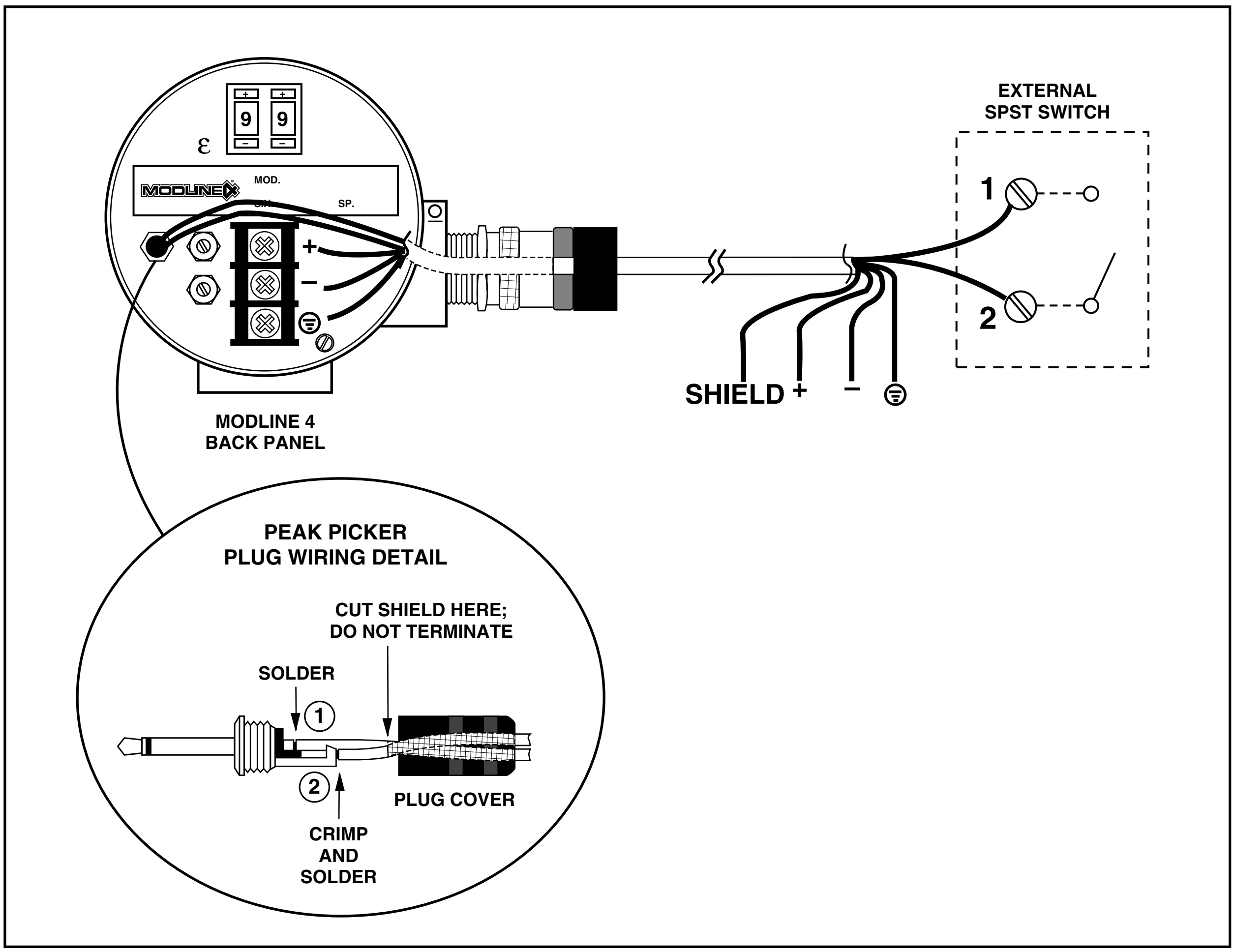


FIG. 2.23 – PEAK PICKER CABLE AND SWITCH WRING

2.16 INSTALLATION CHECKLIST

To ensure accurate, reliable, and trouble-free operation, check your installation for the following:

- ❑ Ensure proper dc supply voltage is used.
- ❑ Check wiring polarity of system component connections.
- ❑ Ensure all loop components are calibrated for 4 to 20 mA and scaled for temperature range of the MODLINE 4.
- ❑ Ensure that the loop for the load devices is grounded at only one point.
- ❑ Ensure temperature of MODLINE 4 case will not go beyond rated limits.
- ❑ Ensure MODLINE 4 has been properly grounded.
- ❑ Ensure proper window material has been selected for process sight window (if used).
- ❑ Ensure that the target fills the field of view of the MODLINE 4.
- ❑ Ensure that no obstructions are in the Cone of Vision.

3.1 INTRODUCTION

The following instructions explain how to place the MODLINE 4 system in operation. Most of these instructions are related directly to IRCON components. If you are using other components be sure to follow any special instructions provided by the manufacturer.

For information and suggestions on various measurement situations, refer to the Applications Guide (Section 6) for your instrument series.

If you run into any problems, review the installation procedures. Make sure you have completed all wiring and observed all precautions. Refer to the trouble shooting instructions in Section 4 if trouble persists.

3.2 INITIAL ADJUSTMENT

Before turning on power, observe the control settings on the back panel of the MODLINE 4 and any indicators, controllers or other instruments in the system. Fig 3.1 shows the location and brief descriptions of the MODLINE 4 controls.

If the MODLINE 4 has a Peak Picker (Block D of Model No. = 1), it must be in the Direct Mode for the initial observations. The Peak Picker Plug (Fig. 3.1, bottom) must be in its jack. If you have wired an external switch to this plug as in Section 2.1 3, the external switch must be open.

3.3 EMISSIVITY SETTING

The emissivity (ε) control setting of the MODLINE 4 must match the emissivity of the material being measured to obtain accurate temperature readings.

If you know the emissivity value of the target material, set the ε control to the known value. You are ready to proceed to the next section.

If you do not know the target emissivity, you can determine it in several ways.

a. Refer to the tables in the Applications Guide (Section 6). Set the emissivity control as recommended for the material you plan to measure.

b, In a test setup, imbed an accurate thermocouple just below the front surface of a sample of the material to be measured and heat the sample. Simultaneously reading the temperature shown by the thermocouple (in a stabilized temperature condition) and observing the surface of the MODLINE 4, adjust the emissivity control until the meter reading obtained corresponds to the thermocouple temperature.

c. In a test setup, apply a uniform coating of a material with known emissivity to a part of the surface of a sample of the material to be measured.

With the emissivity control set to the known emissivity of the coating, heat the sample and observe the temperature (in a stabilized temperature condition) of the coated area, Now view the uncoated surface and adjust the emissivity control until you read the same temperature. The new setting is the true emissivity of the uncoated surface.

d. If you are unable to arrive at a suitable value, contact IRCON Applications Engineering. We can advise you of the correct emissivity setting from either laboratory tests on the sample you submit or from previous experience.

While all MODLINE 4 instruments are capable of emissivity settings of 0.10 to 0.99, it is not always adviseable to use the lower emissivity settings.

Section 3 — OPERATION

Potential interference and temperature measurement errors in any given measurement situation are aggravated by a combination of decreasing target emissivity and decreasing target temperature compared to surrounding temperatures. At target temperatures below 400˚F (200˚C), the general trend of temperature /emissivity combinations to be avoided is as follows:

Temperature	Avoid Emissivity Settings Below
350°F/175°C	0.10
300°F/150°C	0.30
250°F/120°C	0.50
200°F/90°C	0.70
150°F/65°C	0.90

IMPORTANT! For Series 43 instruments, emissivity must be greater than 0.9 for measurements in which temperature will be less than 300°F (150°C).

Measurements *may* be made under these conditions, but special precautions will undoubtedly be necessary and measurement problems may be anticipated. If you are operating under these conditions and encounter measurement problems, contact IRCON Technical Service for advice.

3.4 EFFECT OF WINDOWS ON EMISSIVITY SETTING

If you view your target through a window, a certain percentage of the target radiation will be reflected or absorbed by the window material and will not reach the MODLINE 4. To compensate for the window loss,multiply the target emissivity, ε_T, by the transmittance of the window, τ_W, and set the ε control to this value, ε_{SET}.

Example: A target with an emissivity of 0.80 is viewed through a window with 90% transmittance.

$$\varepsilon_{SET} = \varepsilon_T \times \tau_W$$
$$= 0.80 \times 0.90$$
$$= 0.72$$

Transmittance factors for some commercially available window materials are given in Table 3.1.

TABLE 3.1 – WINDOWS FOR MODLINE 4

SERIES	SPECTRUM (µm)	RECOMMENDED WINDOW MATERIAL[1]	TRANSMITTANCE
43	3.43 ±0.07	Synthetic Sapphire	0.88
44 or 22	8 to 14	Germanium[2,3]	≥0.90
45	3.7 to 4.0	Synthetic Sapphire	0.88
46	2.0 to 2.6	Fused Quartz[3,4]	0.94
47	4.8 to 5.2	Calcium Fluoride	0.94
48	7.5 to 8.5	Calcium Fluoride	0.92

NOTES:
1. Optical grade, 1/8-inch thick, polished to “plate glass” finish.
2. Requires anti-reflection coatings, optimized for 8 to 14 µm, applied to both surfaces. This window is very expensive and requires careful handling.
3. Do not exceed 1/8-inch thickness or the transmittance will be degraded.
4. Water-free quality. General Electric Type 124 or equivalent.

RECOMMENDED SOURCES:

Bond Optics, P.O. Box 422, Etna Road, Lebanon, New Hampshire 03766
Adolph Meller Optics, P.O. Box 6001, Providence, Rhode Island 02940
Janos Technology Inc., HCR#33, Box 25, Route 35, Townshend, Vermont 05353-7702
Karl Lambrecht Corp., 4204 Lincoln Avenue, Chicago, Illinois 60618

EMISSIVITY (ε)
Range .10 to .99

Two-digit "press to change" digital switch used to adjust the electronic circuits to match the emissivity to the material being measured.

Response Time
Range 0.15 to 10 seconds

Potentiometer used to adjust the electronics circuits for the most suitable response to temperature changes. Use low setting to "track" rapid changes. Use higher setting to get a smooth, average temperature display.

BASIC MODLINE 4
(Model No. Block D = 0)

EMISSIVITY (ε)
Range .10 to .99

Two-digit "press to change" digital switch used to adjust the electronics circuits to match the emissivity to the material being measured.

PEAK PICKER PLUG (See Text)

PEAK PICKER DECAY TIME
Range 15 seconds to 30 minutes for Full Scale Decay

Potentiometer used to adjust the time it takes for a full scale signal to decay to zero scale value. Rotate in direction of arrow (clockwise) to increase decay time. Rotate in opposite direction (counterclockwise) to decrease decay time.

RESPONSE TIME
Range 0.15 to 10 seconds

Potentiometer used to adjust the electronic circuits for the most suitable response to temperature changes. Use low setting to "track" rapid changes. Use higher setting to get a smooth, average temperature display. Rotate in direction of arrow (clockwise) to increase response time. Rotate in opposite direction (counterclockwise) to decrease response time.

MODLINE 4 WITH PEAK PICKER OPTION
(Model No. Block D = 1)

FIG. 3.1 – QUICK GUIDE TO CONTROLS

3.5 INITIAL OBSERVATION

NOTE: **For Series 43 Models 43-04F and 43-02C, allow a 15-minute warm-up time before proceeding with any observation or adjustment.**

With all initial adjustments complete, you are ready to apply power to the MODLINE 4 and any related equipment. As heated object moves into the field of view, the MODLINE 4 will respond to temperatures within its temperature range. If you have the IRCON Model AI-4 Analog Indicator or equivalent, the pointer will move upscale as the lower inscribed temperature is reached. If you have a digital readout such as the IRCON Model IDP-4 Digital Indicator, the temperature will be displayed on the readout.

If you are using a recorder with a fast response time, you may note that it is not plotting a straight line. This doesn't necessarily mean the instrument is faulty. You may be reading surface temperature variations especially if the target material is moving.

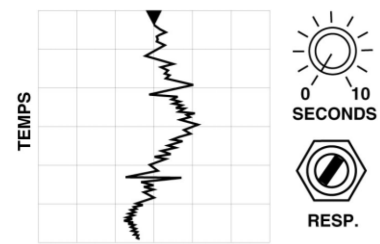
3.6 RESPONSE TIME ADJUSTMENT

The temperature signal outputs have a full scale step response time from 0.15 sec to 10 sec as adjusted by the Response Time control on the panel of the MODLINE 4.

Fig. 3.2 illustrates the effect of response time as it might be displayed by a strip chart recorder. Notice that longer response times tend to average out signal fluctuations and produce more constant signal outputs. On an analog or digital indicator, this would give a more stable pointer action or less digital "bounce."

As you observe the temperature readings on your indicator, adjust the Response Time control to provide the most useful temperature information without any distracting "jitter." For instruments with Peak Pickers, insert a small screwdriver in the slot on the potentiometer and turn to the desired setting.

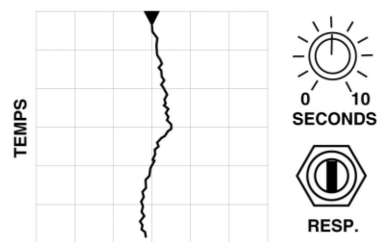
FAST RESPONSE



TEMPERATURE

Signal follows variation as fast as 150 milliseconds. Indicator with equally fast response tracks temperature changes plus noise signals in the system.

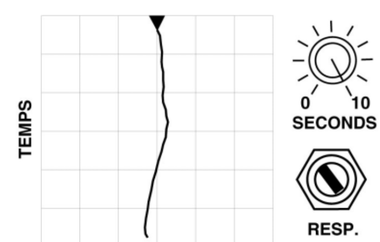
MEDIUM RESPONSE



TEMPERATURE

Signal follows slow temperature changes, but is affected less by fast changes.

SLOW RESPONSE



TEMPERATURE

Signal follows slow temperature changes, but is affected less by fast changes.

NOTE: **Control settings for both Standard models (calibrated control) and Peak Picker models (slotted potentiometer) shown. Disregard illustration that does not apply to your model**

FIG. 3.2 – EFFECT OF RESPONSE TIME ON TEMPERATURE SIGNAL

3.7 PEAK PICKER OPERATION

If your MODLINE 4 includes the Peak Picker option (Block D of the Model Number = 1), you may want to use it in certain measurement situations:

a. If the workpiece you are measuring is moving and is in the field of view for only a brief period of time;

b. If a succession of small parts is to be viewed with variable spacing between them;

c. If the temperature of a moving workpiece varies because of slag, oxides, etc., but you wish to know the highest temperatures;

d. If the line of sight between the instrument and the workpiece is momentarily or periodically interrupted, as by a moving piece of machinery or bursts of steam or smoke.

Fig. 3.3 illustrates the Peak Picker action. The Peak Picker circuitry responds to the highest instantaneous value of temperature and holds this value even if the temperature source is interrupted by one of the conditions listed above.

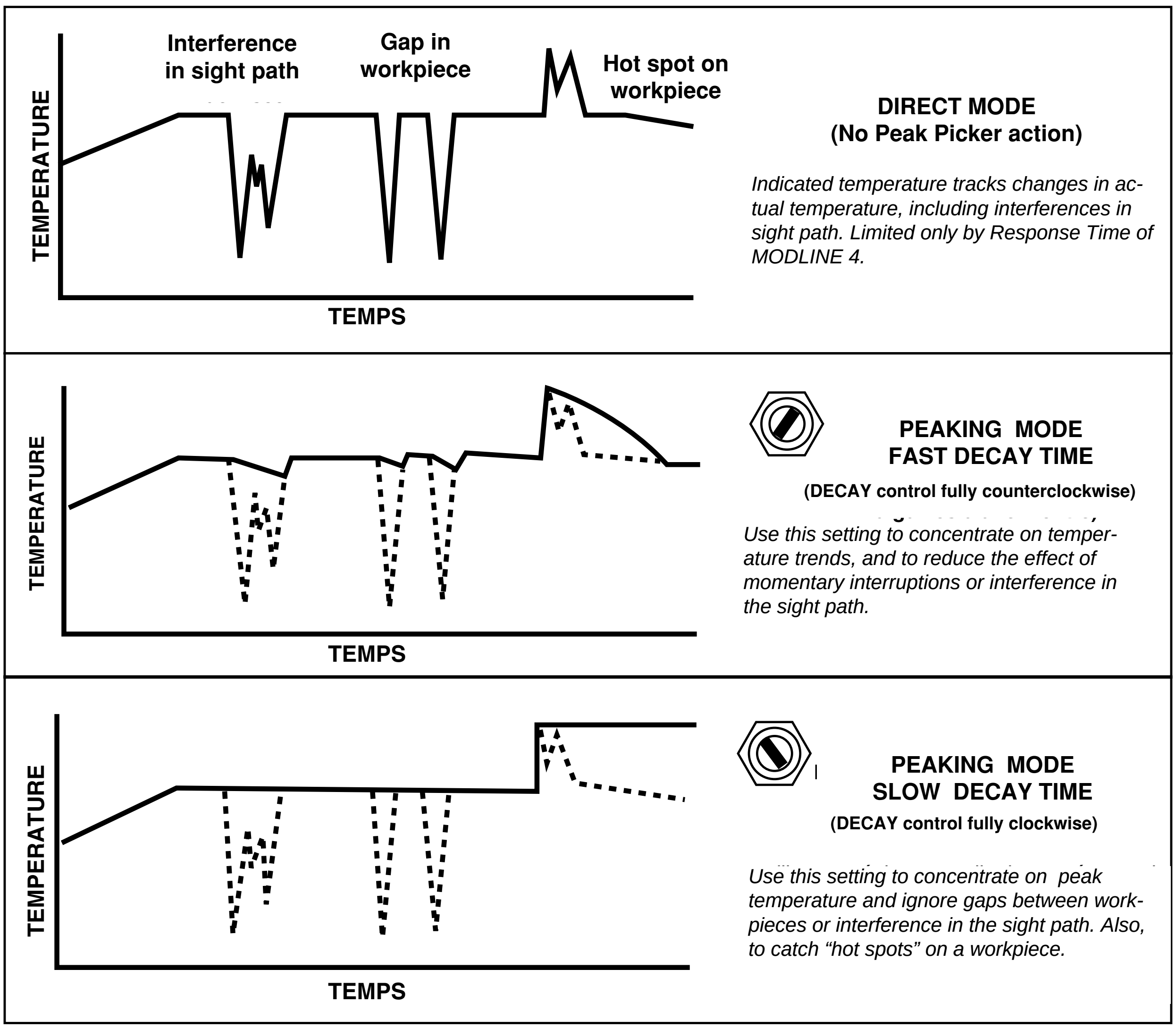


FIG. 3.3 – EFFECT OF PEAK PICKER ON TEMPERATURE INDICATION

The indicated temperature (solid line) rises almost instantly, depending on the response time of the MODLINE 4, to follow the peaks in actual temperature (dashed line) in the field of view. This indicated temperature decays at a rate determined by the setting of the Peak Picker Decay Time control on the back panel. Fig. 3.3 shows the effect of changing the decay time

To operate the Peak Picker, first place the Peak Picker plug in its jack on the back panel, and if you have wired an external switch to this plug, open the switch for at least 15 seconds. This "dumps" the peaking circuits and updates the circuitry to the temperature being observed at the time. Close the switch (or remove the plug from its jack) to place the circuits in the Peaking mode

Adjust the Peak Picker Decay Time control to set the desired decay time At the extreme counterclockwise position is the fastest decay, approximately 15 seconds for a full scale indicated value to decay to zero scale if the source is interrupted completely.

At the extreme clockwise position you will observe the slowest decay rate, approximately 30 minutes for full scale decay. Adjustment somewhere in between these extremes will yield the decay you need for your particular measurement situation.

This peak signal reading may be returned to the instantaneous value at any time by opening the external switch. This switch may be controlled manually, or it may be operated by a microswitch installed in the process or by a timer at desired intervals. In the Direct mode the circuit follows actual temperature variations as they occur.

NOTE: If you have not wired an external switch, you can remove the Peak Picker Plug from its jack to switch to the Peaking mode, and insert it in the jack to switch to the Direct mode.

3.8 CLOSING THE ENCLOSURE

When all connections have been made, and when you have adjusted all controls, place the cap on the back panel of the enclosure to shield the connections and protect the controls from tampering.

Align the thread of the cap with those on the back panel of the enclosure. Then, tighten the cap by hand. Use a bar or rod in the torquing slots (standard enclosure) or against the torquing studs (water-cooled enclosure) to ensure a firm seal.

4.1 ROUTINE MAINTENANCE

Routine Maintenance is essential for reliable, trouble-free operation. It consists of a thorough inspection and “tune-up” at regular intervals to keep the instrument working efficiently and head off problems before they occur.

Most service problems are caused by control misadjustment, improper instrument positioning, dirty optics, and other conditions that will be caught and corrected by an orderly maintenance program.

The checklist below will help you develop a maintenance routine suitable for your installation.

- ☐ Check control settings on the MODLINE 4, and on any other instruments in the system. Make sure controls are set correctly for the process being measured.

  IMPORTANT! Do not vary control settings indiscriminately to compensate for conditions such as dirty optics.
- ☐ Check for proper alignment. Make sure there are no obstructions in the optical path between the MODLINE 4 and the target.
- ☐ Check lens and clean if necessary. Refer to lens cleaning instructions in Section 4.2.
- ☐ Make sure the MODLINE 4 is not overheated. (Refer to Section 1.6 for operating temperature limits for your MODLINE 4 model.) If water cooling and/or air purge accessories are used, make sure there is adequate flow of cooling water and/or clean, dry air.
- ☐ Make sure all connections are secure.
- ☐ Check signal cables for any signs of mechanical damage or overheating.

4.2 LENS CLEANING

The MODLINE 4 uses an anti-reflection coated lens made from either silicon or germanium, depending on the model. The lens is accessible for cleaning from the front end of the casting and does not require removal.

To clean the lens, use clean, laboratory-grade isopropyl alcohol and a clean, soft, lint-free cloth or cotton swab. Dampen the cloth with alcohol and very gently swab the surface of the lens. Be sure to clean the entire exposed surface of the lens.

Dry the lens with a clean, dry, soft cloth. Repeat the procedure if necessary.

After repeated cleanings, some minor scratches may appear on the lens. These minor scratches are purely cosmetic and will not affect the instrument. However, improper cleaning or other abuse may damage the anti-reflection coating to the point where the lens must be replaced. The unit should then be returned to the nearest service center for repair or calibration.

The frequency of lens cleaning will depend on the environment at the point of installation. Air purging will reduce the necessity of frequent cleaning in dusty, dirty areas.

⚠ CAUTION ⚠

Risk of Personal Injury

When this instrument is being used in a critical process that could cause property damage and personal injury, **the user should provide a redundant device or system that will initiate a safe process shutdown in the event that this instrument should fail.** The user should follow NEMA safety guidelines in the appendix of this manual.

TABLE 4.1 – MODLINE 4 SYSTEM TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSE/RECOMMENDED ACTION
No temperature indication *(Target known to be at a temperature within the MODLINE 4 range)*	1. Check for proper dc power supply voltage to system. 2. Ensure loop wiring is correct a) Check for proper polarity of system component connections. b) Ensure no opens or shorts exist in wiring. c) Make sure loop is grounded at one point only. 3. Ensure MODLINE 4 has unobstructed view of target and correct window materials are used. 4. Check that the MODLINE 4 is not being operated at temperatures beyond its case operating temperature range (above maximum or below minimum): minimum limit: 32°F (0°C) for all models* maximum limit: 150°F (66°C) for Series 43* through 48, or 130°F (54°C) for Series 22, in standard enclosure; 400°F (204°C) for all series in water cooled enclosure.
Incorrect temperature indications *(Compared to readings of some reliable standard of known accuracy)*	1. Ensure components in system loop are calibrated for 4 to 20 mA and scaled to temperature range of the MODLINE 4. 2. Ensure dc power supply voltage is correct. 3. Ensure MODLINE 4 has unobstructed view of the object being measured. Target must be large enough to fill the MODLINE 4 field of view. 4. Check that the instrument's lens and process sight window (if used) are clean. 5. Ensure ε setting is correct. 6. Ensure that the MODLINE 4 is not receiving reflected infrared energy from objects surrounding the target. This occurs when viewing low emissivity targets which act as reflectors or partial mirrors. (See Section 6.) 7. Ensure that the MODLINE 4 is not receiving transmitted energy from objects behind the target. (See Section 6.) 8. Check that the MODLINE 4 is not being operated at temperatures beyond its case operating temperature range (above maximum or below minimum): minimum limit: 32°F (0°C) for all models* maximum limit: 150°F (66°C) for Series 43* through 48, or 130°F (54°C) for Series 22, in standard enclosure; 400°F (204°C) for all series in water cooled enclosure.

(Continued)

TABLE 4.1 – MODLINE 4 SYSTEM TROUBLESHOOTING (CONTINUED)

SYMPTOM	POSSIBLE CAUSE/RECOMMENDED ACTION
Erratic operation *(Target known to be at stable temperature)*	1. Check for loose, intermittent connections. 2. Ensure MODLINE 4 case is properly grounded. 3. Ensure loop is grounded at one point. 4. Use shielded cable that has shield returned to earth ground. 5. Separate system wiring from power or r-f wiring. 6. Use a “clean” instrumentation power line. 7. Check that the MODLINE 4 is not being operated at temperatures beyond its case operating temperature range (above maximum or below minimum): minimum limit: 32°F (0°C) for all models* maximum limit: 150°F (66°C) for Series 43* through 48, or 130°F (54°C) for Series 22, in standard enclosure; 400°F (204°C) for all series in water cooled enclosure. 8. Determine if large amounts of smoke or steam are “interfering” with measurement. If MODLINE 4 has a Peak Picker (Block D of Model No. = 1), operation in Peaking mode may overcome this problem.

**Exception: for Series 43, Models 04F, 05F, 02C, and 03C, case operating temperature range is 50 to 113°F (10 to 45°C).*

4.3 SYSTEM TROUBLESHOOTING

If trouble is encountered in obtaining temperature readings after installation of the system, consult Table 4.1. If necessary, call or write for further assistance. For instrument services, contact IRCON Technical Services. For applications assistance, contact IRCON Sales Applications Engineering.

4.4 CALIBRATION SERVICE

The MODLINE 4 is calibrated against precision laboratory standards and “burned in” for a full week before shipment to ensure accurate temperature measurements throughout the operating range.

To preserve this accuracy, each MODLINE 4 should be recalibrated periodically on a Blackbody standard. We recommend recalibration of this type on a yearly basis.

You can have your MODLINE 4 calibrated in our Pyrometer Service Center. Calibration traceable to the National Institute of Standards and Technology (National Bureau of Standards) is an available option. If you prefer, IRCON can provide a Model BCH, BCL or BCN Blackbody Calibration System that lets you perform your own calibration. Complete instructions are supplied with the unit. You can also arrange for an IRCON Field Service Engineer to train your technicians in calibration procedures. Call IRCON Technical Services for details.

NOTES:

Section 5 — OPTIONAL ACCESSORIES

5.1 GENERAL

This section contains information about the basic MODLINE 4 accessories. These include Analog and Digital Indicators, Power Supplies, and Accessories to facilitate mounting and provide environmental protection for the MODLINE 4. The more commonly used accessories are described in this section. More specialized accessories, such as sight tubes, are described in Product Bulletin PB0070, available on request.

Section 5 — OPTIONAL ACCESSORIES

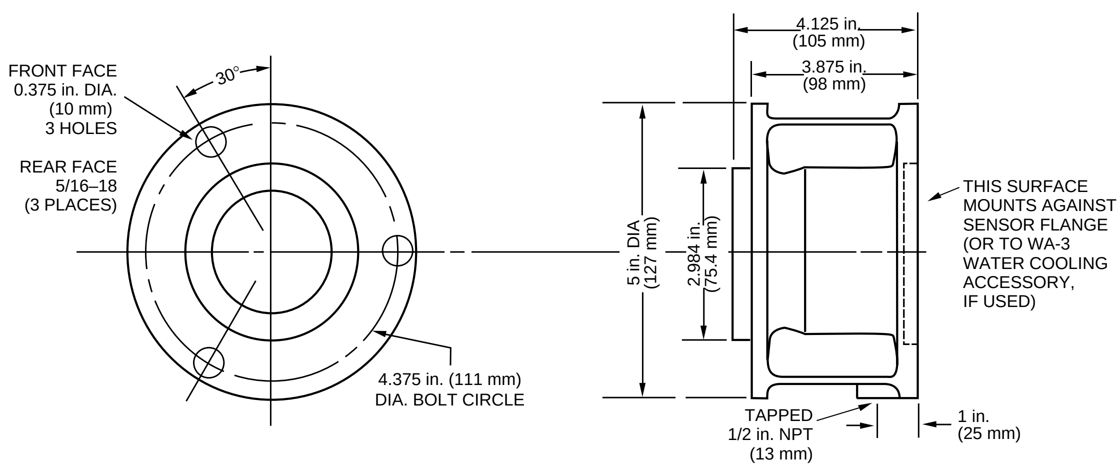
5.2 MODEL AA-3 AIR PURGE ACCESSORY

(Used only with MODLINE 4 with standard enclosure. For Series 43-04F or 43-02C only. DO NOT combine with Model WA-3 Water Cooling Accessory.)

A Model AA-3 Air Purge Accessory provides a stream of clean air to prevent smoke, particles, steam, etc., from collecting on the lens. This accessory bolts to the front flange of a MODLINE 4 and can be used in combination with other accessories such as a Model WA-3 Water Cooling Accessory.

A 1/2-inch NPT tapped hole is provided for air intake. Air flow of about 5 ft^3/min. is suitable for most applications.

PHYSICAL DIMENSIONS



ASSEMBLY NOTES:

Two gaskets and three 5/16–18 NC flanged, hex head bolts are supplied. Insert bolts through unthreaded holes on front flange of AA-3 and bolt to mounting support (or additional accessory, if used). Insert gasket(s)* in recess at rear, and bolt MODLINE 4 flange (or WA-3 Water Cooling Accessory, if used) to rear flange of AA-3. Use bolts supplied with MODLINE 4 (or WA-3).

* Use one or two gaskets, as needed, to form good seal and still allow flange surfaces to touch.

NOTE: Refer to Section 2 for MODLINE 4 grounding information. If necessary, use appropriate insulation between flanges of MODLINE 4 and AA-3, and attach with insulating hardware.

Section 5 – OPTIONAL ACCESSORIES

5.3 MODEL TV-VIEW DIGITAL INDICATOR / POWER SUPPLY

The Model TV-VIEW digital meter is a power supply and a digital indicator. It can be scaled for any MODLINE 4 range, both °C or F. It provides 24 Vdc power to the sensor and accepts the 4-20 mA output.

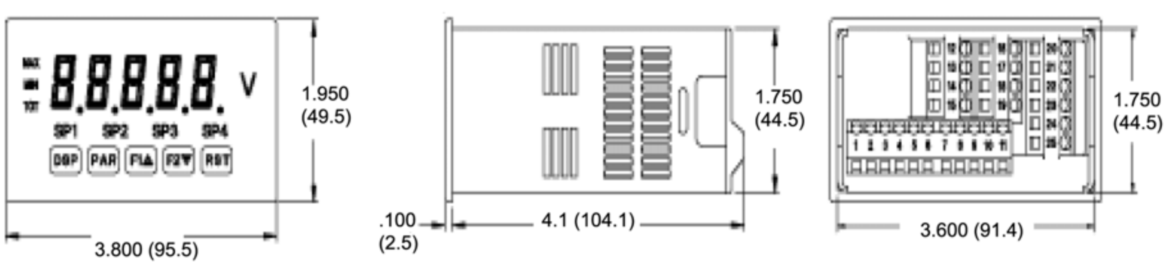
SPECIFICATIONS

Temperature Ranges:	All Modline 4 ranges °C or F
Accuracy:	± 12% of reading
Loop Current Supply:	50 mA Max
Output Voltage:	± 24 Vdc, ± 5%
Ambient Range:	0 to 50°C
Digits:	5 digit Red LED 19,999 to 99,999
Conversion Rate:	20 readings/second
Input Power:	TV-VIEW-VAAC, 85–250 VAC, 50/60 Hz, 15 Va TV-VIEW-VADC, 11-36 Vdc, 11 W
Options:	Alarms RS232, RS485 Output 0-10 Vdc / 4-20 mAdc

PHYSICAL DIMENSIONS

Dimensions in inches (mm)

Note: Recommended maximum clearance for mounting clip installation (behind panel) is 2.1 inches (53.2 mm) high x 55 inches (140 mm) wide.



Section 5 – OPTIONAL ACCESSORIES

5.4 MODEL PS4-24 POWER SUPPLY

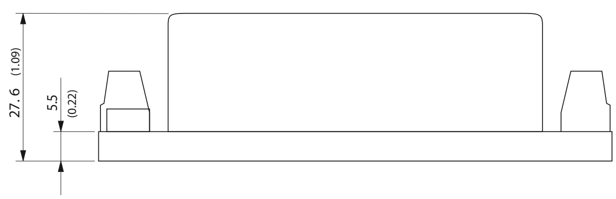
The PS4-24 power supply delivers isolated dc power and provides short circuit and overload protection.

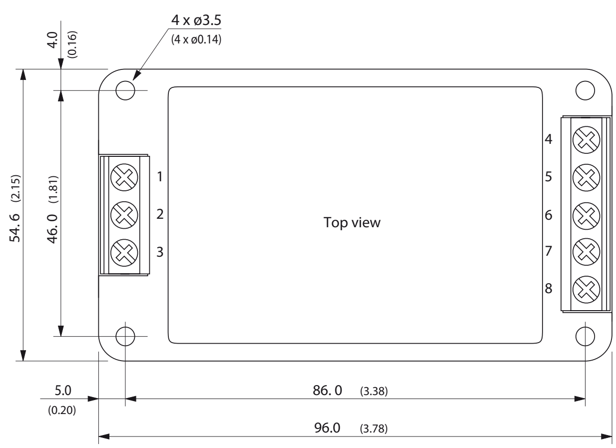
Technical Data

Protection class:	class I
Operating temperature range:	-25°C to 60°C (-13 to 140°F)
AC input:	100 to 240 VAC ± 10% 47 - 440 Hz
- external fuse (required):	1.5 A slow blow type (recommendation)
DC output:	24 VDC / 840 mA
	derate 3%/°C above 50°C (122°F)
Wire cross sections input/output:	1.5 mm² max.

⚠ WARNING ⚠

To prevent electrical shocks, the power supply must be used in protected environments (cabinets)!





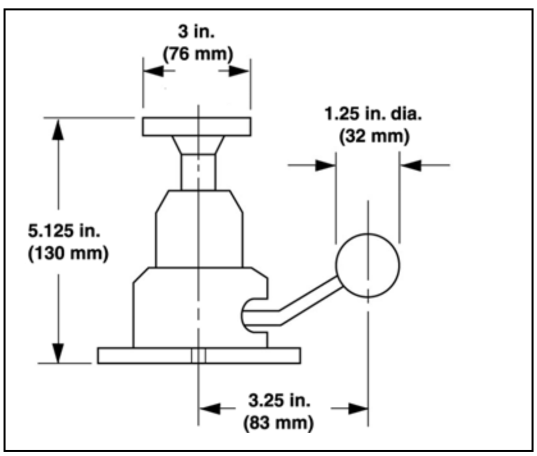
Section 5 – OPTIONAL ACCESSORIES

5.5 MODEL SB-1 SWIVEL MOUNTING BASE

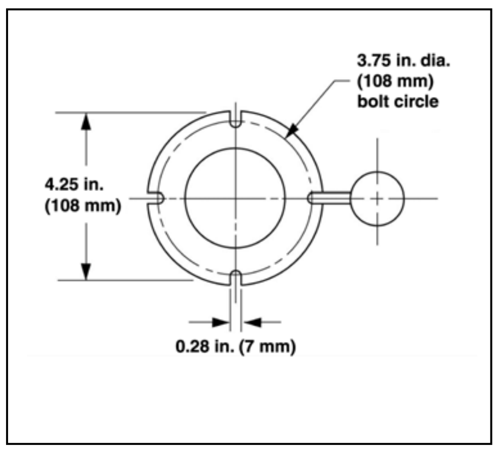
The swivel mounting base may be used for installations that require good line of sight adjustment capability. device permits tilting and panning motions and may be locked securely in place when optical alignment is completed. *Note: Don't use the SB-1 or the EE-2 accessories since they are too heavy to hold the swivel base securely.*

There are three 1/4 x 20 NC hex head bolts and 1/4 inch split ring lock washers that are supplied with each swivel base. Insert two bolts with lock washers through mounting plate holes into corresponding threaded holes on the sensor base and tighten the bolts.

Attach the base to the desired mounting surface using customer-supplied mounting hardware. Refer to grounding information in the manual when planning the mounting procedure.



SB-1 swivel base side view



SB-1 swivel base bottom view

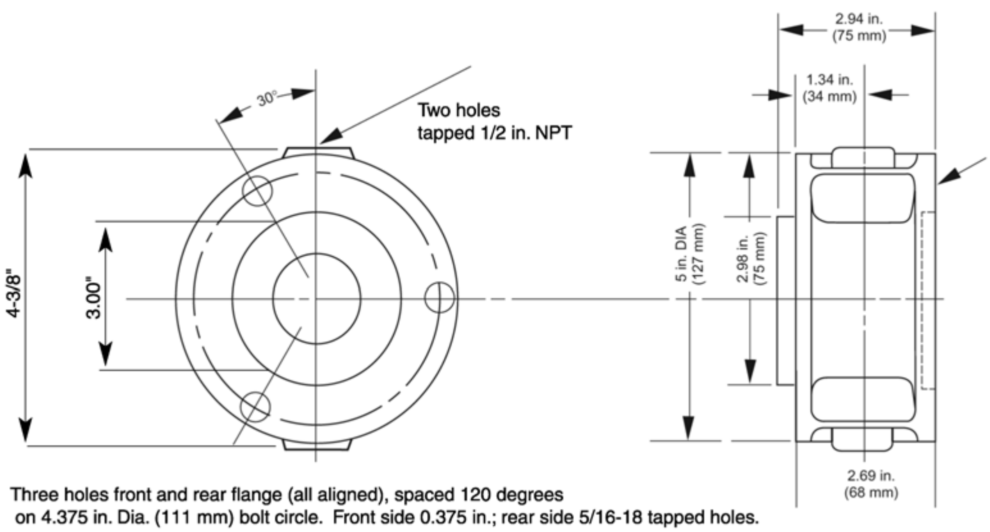
Section 5 – OPTIONAL ACCESSORIES

5.6 MODEL WA-3 WATER COOLING ACCESSORY

Used only with Modline 4 and standard enclosure. For Series 43-04F or Series 43-02C only *(do not combine with Model WA-3 Water Cooling accessory).* Model WA-3 water cooling accessory is recommended where ambient temperatures are expected to exceed the maximum rating of the Modline 4. Nominal water flow of 10 to 20 gallons per hour at water temperatures below 90°F (32°C) is suitable for most applications. The cooling effect must be sufficient to keep the case temperature of the instrument below its maximum rating.

Two 1/2 inch NPT tapped holes accept water intake and outlet pipes. A matched flange permits bolting to the Modline 4 and other standard accessories. Where high ambients and moist atmospheres are encountered, the use of an AA-3 Air Purge accessory with a WA-3 water cooling accessory prevents moisture condensation on the lens of the Modline 4.

PHYSICAL DIMENSIONS



ASSEMBLY NOTES

Two gaskets and three 5/16-18 NC flanged hex head bolts are supplied. Insert bolts through unthreaded holes on front flange of WA-3 and bolt to mounting support (or additional accessory if used). Use one or two gaskets as needed, to form a good seal and still allow flange surfaces to touch. Insert the gasket(s) in recess at rear and bolt the sensor flange to the WA-3 rear flange. *Note: use bolts supplied with instrument. Refer to Section 2 for grounding information. If necessary, use appropriate insulation between flanges of Modline 4 and WA-3 and attach with insulating hardware.*

Section 6 — APPLICATIONS GUIDE

6.1 INTRODUCTION

MODLINE 4 is a precision measuring instrument built for rugged service and ease of operation. When installed and maintained with reasonable care, it will give you reliable, trouble-free service in a wide variety of applications.

In this section we offer some guidelines to further ensure accuracy and reliability. We urge you to review this information to make sure your instrument gives you the results it is capable of.

BACKGROUND

Make sure the infrared energy being measured is emitted by the target only. Energy picked up from some other source is called background. It combines with the true target energy to cause measurement errors.

Causes of background error are as follows:

- unresolved targets
- energy transmitted through the target
- energy reflected off the surface of the target

Unresolved Targets

An unresolved target can mean any of three things: (1) the spot size is larger than the target size, (2) the optical axis of the MODLINE 4 is not centered on the target, or (3) there is an interfering object in the sight path. Any of these conditions will cause the detector to "see" something besides target radiation and to produce measurement errors.

To avoid problems: (1) make sure the spot size is smaller than the target size, (2) aim the MODLINE 4 so its optical axis is centered on the target, and (3) make sure there are no obstructions in the sight path. Review Section 2.9 for details.

Emissivity, Reflectance, and Transmittance

An ideal infrared radiator, called a blackbody, emits the maximum possible amount of infrared energy when heated to any given temperature. It has an Emissivity (ε) of 1.0. It does not reflect or transmit background energy (its Reflectance and Transmittance values are zero).

The MODLINE 4 is factory calibrated using blackbody standards. However, the targets you deal with in practice are non-blackbodies. Their Emissivity values are less than 1.0, which means they emit some traction of the infrared energy a blackbody would emit at a given temperature. You must compensate for this difference by adjusting the Emissivity (ε) control for a setting of less than 1.0.

Non-blackbodies exhibit two potential causes of background error: Reflectance (***r***) and Transmittance (τ).

Reflectance causes the target to act as a mirror, and it will reflect infrared energy generated by some other source (e.g., a furnace wall or heater element). If the MODLINE 4 picks up the reflection, measurement errors will result.

Reflectance depends on the target material and the condition of its surface. Flat, smooth surfaces tend to have larger reflectance values than roughened surfaces of the same material.

Reflectance problems may be reduced by changing the viewing angle so that the reflection is not picked up by the MODLINE 4 or by the use of sight tubes or some other form of shielding. (See Fig. 6.1.) Contact IRCON Applications Engineering for further recommendations.

Transmittance means the target is not completely opaque at the operating wavelength of the MODLINE 4, so it may act as a window for infrared emission from objects behind it (e.g., an oven wall or heater element).

Transmittance depends on target material and thickness. For a given material at a given wavelength, transmittance is inversely related to thickness.

Transmittance problems are sometimes corrected by changing the viewing angle so that the background source is not directly behind the target, by selecting a different measurement point away from the background source, or by inserting a shield behind the workpiece. (See Fig. 6.2 for examples.) If you are faced with a persistent transmittance problem, contact IRCON Applications Engineering for suggestions.

Section 6 — APPLICATIONS GUIDE

Emissivity (ε), Reflectance (*r*), and Transmittance (τ) are related as follows:

$$\varepsilon = 1 - \tau - r$$

Maximum accuracy is possible when ε = 1.0 (blackbody condition). In this condition there is no reflection and no transmission of background energy to cause measurement errors.

As Emissivity decreases it is harder to get accurate readings because Reflectance and Transmittance become more pronounced. Use caution when attempting to measure materials with Emissivity known to be 0.80 or less. Take any appropriate steps to shield the MODLINE 4 from background radiation. Contact IRCON Applications Engineering if problems persist.

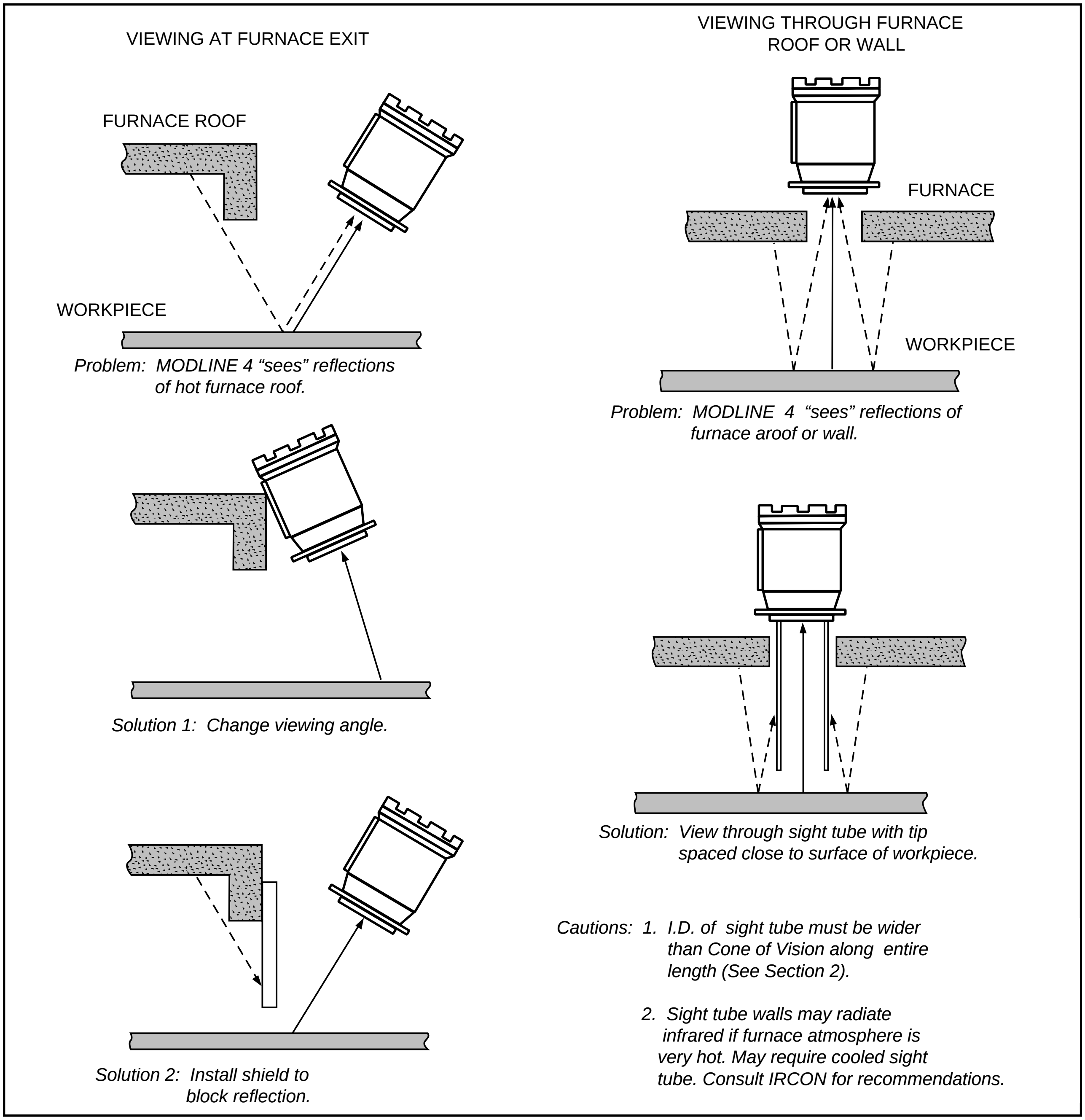


FIG. 6.1 – SOLVING COMMON REFLECTANCE PROBLEMS

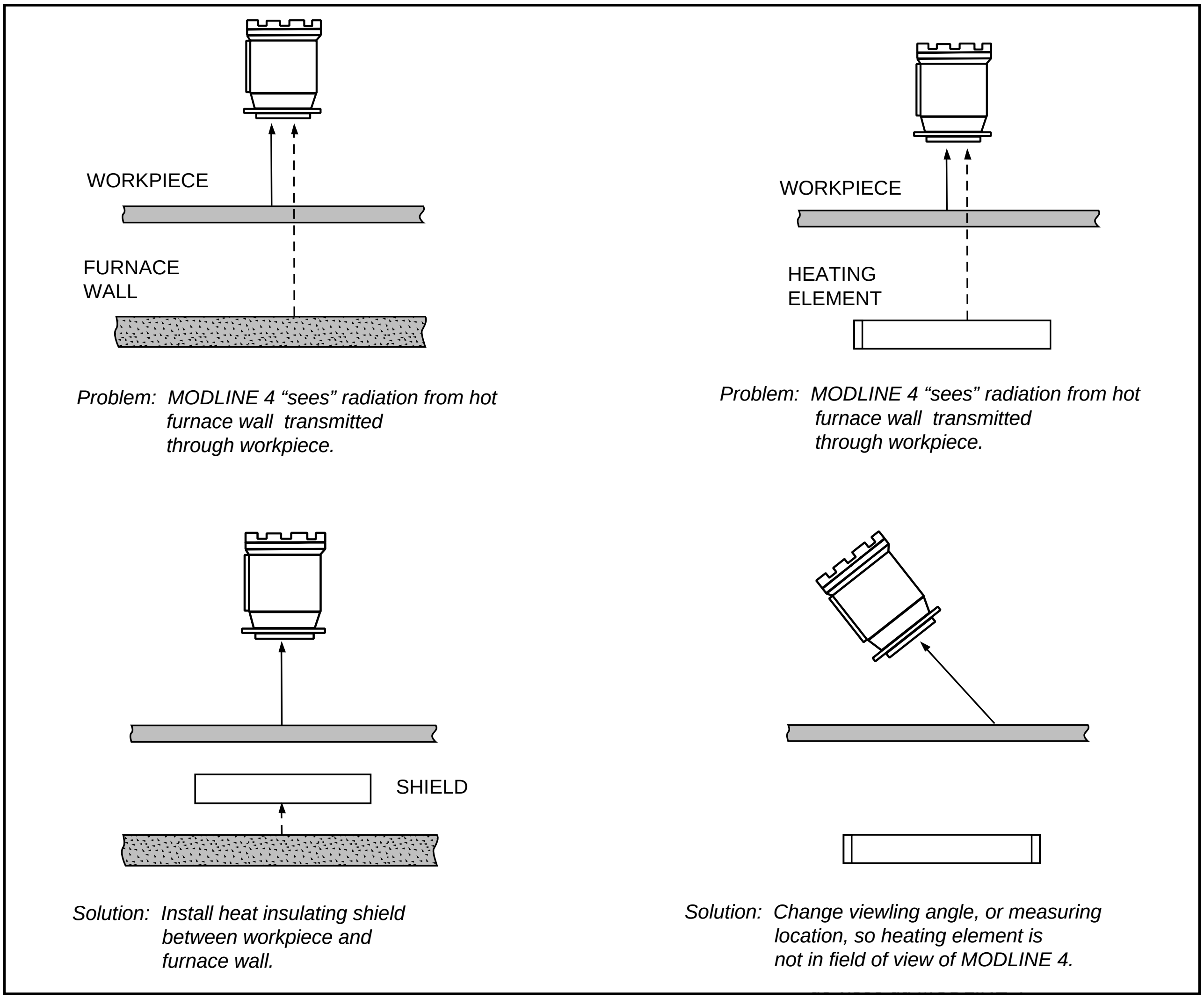


FIG. 6.2 – SOLVING COMMON TRANSMITTANCE PROBLEMS

6.2 EMISSIVITY TABLES

For accurate temperature measurements, you must set the Emissivity (E) control of the MODLINE 4 to the emissivity value of the material you intend to measure. As explained in Section 3.3, one way to determine the correct control setting is to refer to a set of Emissivity Tables. The tables in this section of the manual are provided for this purpose. They are based on actual tests on samples of the materials listed. Tables are provided for each MODLINE 4 instrument series. The materials in each table are grouped according to the classes of materials usually measured by that series (e.g., Plastics; Glass; Building Materials; etc. for Series 44).

To use the Emissivity Tables, go to the appropriate table for your instrument series, and locate the material of interest in that table. Note the value in the Emissivity column and set the ε control to this value.

Be sure to observe any notes or descriptions included in the tables. If your material is not listed, or if you are in doubt about any of the values, contact IRCON Applications Engineering.

TABLE 6.1

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 44 and 22** SPECTRUM: 8 to 14 microns

All specimens in this table are in the following form:

1. Thick enough to reduce Transmittance τ to less than 0.01.

2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
PLASTICS			
ABS, “CYCOLAC”	0.020	0.04	0.96
ACETAL, “DELRIN”	.010	.05	.95
ACRYLIC, “PLEXIGLAS”, “LUCITE”	.010	.05	.95
ALKYDS,"PLENCO"	.010	.05	.95
CELLULOSICS	.010	.05	.95
CELLOPHANE	.010	.05	.95
EPOXY	.006	.05	.95
FLUOROPOLYMERS, "TEFLON"	.015	.06	.94
PHENOLICS, "PLENCO"	.010	.05	.94
POLYAMIDE, “NYLON”	.015	.04	.96
POLYAMIDE, "KAPTON"	.010	.08	.92
POLYCARBONATE, “LEXAN”	.010	.06	.94
POLYESTER, P.E.T., “MYLAR”, “DACRON”	.010	.08	.92
POLYETHYLENE	.15	.04	.96
POLYPROPYLENE	.10	.04	.96
POLYSTYRENE	.040	.04	.96
POLYURETHANE	.010	.05	.95
POLYVINYL CHLORIDE (PVC), “GEON”	.015	.04	.96
LIQUIDS			
WATER	0.002	0.02	0.98
OIL, MINERAL	.080	.03	.97
OIL, ANIMAL OR VEGETABLE	.020	.05	.95
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	0.001	0.10	0.90
CHEMICAL “PYREX”	.001	.15	.85
FUSED QUARTZ	.001	.20	.80

(Continued)

TABLE 6.1 (Continued)

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
METALS, BARE Unoxidized (For oxidized samples of metals, refer to "Composites and Miscellaneous" of Table 6.12.)			
ALUMINUM	Materials in this class are opaque (zero transmittance) at any thickness	0.98	0.02
CHROMIUM		.92	.08
COPPER		.98	.02
GOLD		.98	.02
IRON, CARBON STEEL		.95	.05
LEAD		.95	.05
NICKEL		.96	.04
SILVER		.98	.02
STAINLESS STEEL		.89	.11
TIN		.84	.16
ZINC		.98	.02
(GRAPHITE)		.40	.60

FOR ADDITIONAL EMISSIVITY VALUES FOR SERIES 44 AND 22, SEE TABLE 6.2.

TABLE 6.2

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 44 AND 22** SPECTRUM: 8 to 14 microns

All specimens in this table are in their common physical form — e.g. raw materials like coal, gravel, sand, etc. in their normal granular form; construction products like lumber, paneling, tiles, roofing, etc. in their normal delivered forms.

Unless otherwise noted, these materials have negligible Transmittance τ in their common form. Any difference between the listed Emissivity ε and a "perfect" Emissivity of 1.0 is due to Reflectance r.

TARGET MATERIAL	EMISSIVITY ε
WOOD PRODUCTS	
PAPER, WOOD PULP (0.003" THICK)	~0.80
PAPER, BOND STATIONERY (0.003" THICK)	~.80*
PAPER, CLAY FILLED (0.012" THICK)	.85
CARDBOARD	.88
WOOD, SOFT OR HARD	.90
HARDBOARD	.92
BUILDING MATERIALS	
ASPHALT, MACADAM	0.98
CLAY, DRY	.90
CLAY , WET	.98
CONCRETE, DRY	.91
CONCRETE, WET	.98
CORK	.98
FIBERGLASS BATTS	.98
FORMICA	.94
GLASS	.90
GRAVEL	.95
LINOLEUM	.96
PAINTED METAL	.75 - .95
PAINTED WOOD, PLASTIC	.96
PLASTIC PANELS	.96
PLYWOOD	.90
ROCK, CRUSHED	.95
ROOFING, COMPOSITION	.95
RUBBER CLOTH	.96
SAND	.92
TILES, CERAMICS	~.80
TILES, RUBBER, PLASTIC	.95

TARGET MATERIAL	EMISSIVITY ε
TEXTILES, FABRICS	
CARPET (COTTON, WOOL, SYNTHETIC)	0.98
FABRICS, CLOSE WEAVE (COTTON, WOOL, SYNTHETIC)	.80 - .95
FUR	.96
LEATHER	.96
PLASTICS	.95
FOODS, FOOD PROCESSING	
BAKERY GOODS	0.98
BATTERS	.98
CANDY	.98
CONFECTIONS	.98
DAIRY PRODUCTS	.98
FATS	.98
FRUITS	.98
FLOUR	.98
GRAIN	.98
GRAVIES	.98
JELLIES, JAMS	.98
LIQUIDS	.98
MEATS	.98
OILS	.98
SAUCES	.98
SUGAR	.98
VEGETABLES	.98

(Continued)

TABLE 6.2 (Continued)

TARGET MATERIAL	EMISSIVITY ε
INDUSTRIAL MATERIALS, INORGANIC	
CERAMICS	~0.80
CLAY	.90
CHEMICALS, LIQUID	.95
CHEMICALS, SOLID	.80 - .95
COAL	.98
COKE	.98
FIREBRICK	.85
GLASS	.90
GRAVEL	.95
MINERALS, ORES	.95
SAND	.95
SLAG	.95
STEEL BILLET, OXIDIZED	.82
SLURRIES	.98
WATER, AQUEOUS SOLUTIONS	.98
INDUSTRIAL MATERIALS, ORGANIC	
CARBON BLACK	0.98
CHEMICALS, LIQUID	.96
CHEMICALS, SOLID	.96
COAL, COKE	.98
OILS, FATS, GREASE	.96
PETROLEUM PRODUCTS	.96
PLASTICS	.96
SOLVENTS	.96
WAXES	.96

TARGET MATERIAL	EMISSIVITY ε
COMPOSITES AND MISCELLANEOUS	
CARBON STEEL, OXIDIZED	0.82
DRUGS, PHARMACEUTICALS	.95
FIBERGLASS—EPOXY FORMS	.95
GLASS COATED METAL	.90
NICKEL, OXIDIZED	.85
PAINTED METAL	.75 - .95
PAINTED WOOD	.95
PLASTIC LAMINATED WOOD	.95
PRINTED CIRCUIT BOARDS	.95
RECORDING TAPE	.85
SALT BATH	.95
SANDPAPER	.90
STAINLESS STEEL, OXIDIZED	.85
TOBACCO	.96

TABLE 6.3

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 45** SPECTRUM: 3.7 to 4.0 microns

All specimens in this table are in the following form:
1. Thick enough to reduce Transmittance τ to less than 0.01.
2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	0.40	0.02	0.98
CHEMICAL “PYREX”	0.10	.02	.98
FUSED QUARTZ	1.4	.02	.98
METALS, BARE Unoxidized (For oxidized samples of metals, refer to Table 6.4.)			
ALUMINUM	Materials in this class are	0.97	0.03
CHROMIUM	opaque (zero transmittance)	.75	.25
COPPER	at any thickness	.98	.02
GOLD		.98	.02
IRON, CARBON STEEL		.88	.12
NICKEL		.92	.08
SILVER		.97	.03
STAINLESS STEEL		.83	.17
TIN		.73	.27
ZINC		.93	.07
(GRAPHITE)		.48	.52

TABLE 6.4

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 45** SPECTRUM: 3.7 to 4.0 microns

All specimens in this table are in their common physical form. These materials have negligible transmittance τ in their common form. Any difference between the listed Emissivity ε and a "perfect" Emissivity of 1.0 is due to Reflectance r.

TARGET MATERIAL	EMISSIVITY ε
METALS, Oxidized	
NICKEL, OXIDIZED	0.85
STAINLESS STEEL, OXIDIZED	.85
STEEL OXIDIZED	.82

TARGET MATERIAL	EMISSIVITY ε
MISCELLANEOUS MATERIALS	
COKE	0.98
FIREBRICK	.5 -.9
SLAG	.85

TABLE 6.5

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 46**　　SPECTRUM: 2.0 to 2.6 microns

All specimens in this table are in the following form:

1. Thick enough to reduce Transmittance τ to less than 0.01.

2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	~ 5.	0.03	0.97
METALS, BARE Unoxidized (For oxidized samples of metals, refer to Table 6.4.)			
ALUMINUM	Materials in this class are opaque (zero transmittance) at any thickness	0.97	0.03
CHROMIUM		.66	.34
COPPER		.98	.02
GOLD		.98	.02
IRON, CARBON STEEL		.89	.21
NICKEL		.91	.09
SILVER		.97	.03
STAINLESS STEEL		.78	.22
TIN		.62	.38
TITANIUM		.70	.30
ZINC		.91	.09
(GRAPHITE)		.37	.63

TABLE 6.6

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 46** SPECTRUM: 2.0 to 2.6 microns

All specimens in this table are in their common physical form . These materials have negligible transmittance τ in their common form. Any difference between the listed Emissivity ε and a "perfect" Emissivity of 1.0 is due to Reflectance r.

TARGET MATERIAL	EMISSIVITY ε
METALS, Oxidized	
NICKEL, OXIDIZED	0.85
STAINLESS STEEL, OXIDIZED	.85
STEEL OXIDIZED	.82

TARGET MATERIAL	EMISSIVITY ε
MISCELLANEOUS MATERIALS	
CERAMICS	0.3 - 0.9
COKE	.98
FIREBRICK	.5 - .9
SALT BATH	.96
SILICON CARBIDE	.85
SLAG	.85

TABLE 6.7

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 47** SPECTRUM: 4.8 to 5.2 microns

All specimens in this table are in the following form:

1. Thick enough to reduce Transmittance τ to 0.00

2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
PLASTICS			
ABS, “CYCOLAC”	0.050	0.03	0.97
ACETAL, “DELRIN”	.050	.03	.97
ACRYLIC, “PLEXIGLAS”, “LUCITE”	.050	.03	.97
ALKYDS,"PLENCO"	.040	.03	.97
CELLULOSICS	.040	.03	.97
CELLOPHANE	.040	.03	.97
EPOXY	.025	.03	.97
FLUOROPOLYMERS, "TEFLON"	.25	.02	.98
PHENOLICS, "PLENCO"	.040	.03	.97
POLYAMIDE, “NYLON”	.060	.02	.98
POLYAMIDE, "KAPTON"	.040	.06	.94
POLYCARBONATE, “LEXAN”	.040	.06	.94
POLYESTER, P.E.T., “MYLAR”, “DACRON”	.040	.03	.92
POLYETHYLENE	.30	.04	.96
POLYPROPYLENE	.30	.04	.96
POLYSTYRENE	.25	.03	.97
POLYURETHANE	.040	.03	.97
POLYVINYL CHLORIDE (PVC), “GEON”	.12	.04	.96
LIQUIDS			
WATER	0.005	0.02	0.98
OIL, MINERAL	1.0	.03	.97
OIL, ANIMAL OR VEGETABLE	0.15	.03	.97
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	0.040	0.02	0.98
CHEMICAL “PYREX”	.025	.02	.98
FUSED QUARTZ	.040	.02	.98

(Continued)

TABLE 6.7 (Continued)

TARGET MATERIAL EMISSIVITY	MINIMUM THICKNESS (inches)	REFLECTANCE r	ε
METALS, BARE Unoxidized (For oxidized samples of metals, refer to "Composites and Miscellaneous" of Table 6.8.)			
ALUMINUM	Materials in this class are opaque (zero transmittance) at any thickness	0.97	0.03
CHROMIUM		.81	.19
COPPER		.98	.02
GOLD		.97	.03
IRON, CARBON STEEL		.91	.09
LEAD		.92	.08
NICKEL		.94	.06
SILVER		.97	.03
STAINLESS STEEL		.85	.15
TIN		.76	.24
ZINC		.97	.03
(GRAPHITE)		.28	.72

FOR ADDITIONAL EMISSIVITY VALUES FOR SERIES 47, SEE TABLE 6.8.

Section 6 — APPLICATIONS GUIDE

TABLE 6.8

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 47** SPECTRUM: 4.8 to 5.2 microns

Materials in this table are in their common physical form — e.g. raw materials like coal, gravel, sand, etc. in their normal granular form; construction products like lumber, paneling, tiles, roofing, etc. in their normal delivered forms.

Target materials with Emissivity values less than 1 will reflect and/or transmit to the extent of 1-e . Low values of e (e.g., e<0.8) suggest precautions are in order to prevent background interference from other hot objects in the area.

TARGET MATERIAL	EMISSIVITY ε
WOOD PRODUCTS	
PAPER, WOOD PULP (0.003" THICK)	~0.50
PAPER, BOND STATIONERY (0.003" THICK)	~.50*
PAPER, CLAY FILLED (0.012" THICK)	.75
CARDBOARD	.80
WOOD, SOFT OR HARD	.75
HARDBOARD	.75
BUILDING MATERIALS	
ASPHALT, MACADAM	0.98
CLAY, DRY	.90
CLAY , WET	.98
CONCRETE, DRY	.93
CONCRETE, WET	.98
CORK	.98
FIBERGLASS BATTS	.98
FORMICA	.95
GLASS	.98
GRAVEL	.93
LINOLEUM	.96
PAINTED METAL	0.20 - 0.40
PAINTED WOOD, PLASTIC	.80
PLASTIC PANELS (See Table 6.7 on "Plastics")	
PLYWOOD	.75
ROCK, CRUSHED	.93
ROOFING, COMPOSITION	.95
RUBBER CLOTH	.96
SAND	.97
TILES, CERAMICS	.97
TILES, RUBBER, PLASTIC	.95
WOOD	.75

TARGET MATERIAL	EMISSIVITY ε
TEXTILES, FABRICS	
CARPET (COTTON, WOOL, SYNTHETIC)	0.88
FABRICS, CLOSE WEAVE (COTTON, WOOL, SYNTHETIC)	.60 - .90
FUR	.93
LEATHER	.90
PLASTICS (See Table 6.7 on Plastics")	
FOODS, FOOD PROCESSING	
BAKERY GOODS	0.96
BATTERS	.96
CANDY AND CONFECTIONS	.96
DAIRY PRODUCTS	.96
FRUITS	.96
FLOUR	.94
GRAIN	.94
GRAVIES	.96
JELLIES, JAMS	.98
LIQUIDS	.98
MEATS	.98
OILS (See Table 6.7 on "Liquids")	
SAUCES	.98
SUGAR	.96
VEGETABLES	.98

(Continued)

TABLE 6.8 (Continued)

TARGET MATERIAL	EMISSIVITY ε
INDUSTRIAL MATERIALS, INORGANIC	
CERAMICS	0.98
CLAY	.92
CHEMICALS, LIQUID	.96
CHEMICALS, SOLID	.80 - .95
COAL	.98
COKE	.98
FIREBRICK	.96
GLASS	.98
GRAVEL	.95
MINERALS, ORES	.95
SAND	.98
SLAG	.98
STEEL BILLET, OXIDIZED	.82
SLURRIES	.98
WATER, AQUEOUS SOLUTIONS	.98
INDUSTRIAL MATERIALS, ORGANIC	
CARBON BLACK	0.98
CHEMICALS, LIQUID	.96
CHEMICALS, SOLID	.96
COAL, COKE	.98
OILS, FATS, GREASE (See Table 6.7 on "Liquids")	
PLASTICS (See Table 6.7 on "Plastics")	.96
SOLVENTS (See Table 6.7 on "Liquids")	.96

TARGET MATERIAL	EMISSIVITY ε
COMPOSITES AND MISCELLANEOUS	
CARBON STEEL, OXIDIZED	0.82
DRUGS, PHARMACEUTICALS	.96
FIBERGLASS—EPOXY FORMS	.96
GLASS COATED METAL	.98
NICKEL, OXIDIZED	.85
PAINTED METAL	.20 - .40
PAINTED WOOD	.80
PLASTIC LAMINATED WOOD	.85
PRINTED CIRCUIT BOARDS	.85
RECORDING TAPE	.50 - .80
SALT BATH	.95
SANDPAPER	.85
STAINLESS STEEL, OXIDIZED	.85
TOBACCO	.85

TABLE 6.9

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 48** SPECTRUM: 7.5 to 8.5 microns

All specimens in this table are in the following form:

1. Thick enough to reduce Transmittance τ to less than 0.01

2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
PLASTICS			
ABS, “CYCOLAC”	0.010	0.04	0.96
ACETAL, “DELRIN”	.005	.05	.95
ACRYLIC, “PLEXIGLAS”, “LUCITE”	.002	.03	.97
ALKYDS,"PLENCO"	.005	.05	.95
CELLULOSICS	.002	.05	.95
CELLOPHANE	.003	.05	.95
EPOXY	.004	.04	.96
FLUOROPOLYMERS, "TEFLON"	.010	.03	.97
PHENOLICS, "PLENCO"	.005	.05	.95
POLYAMIDE, “NYLON”	.010	.04	.96
POLYAMIDE, "KAPTON"	.002	.07	.93
POLYCARBONATE, “LEXAN”	.005	.07	.93
POLYESTER, P.E.T., “MYLAR”, “DACRON”	.004	.09	.91
POLYETHYLENE	.10	.04	.96
POLYPROPYLENE	.050	.04	.96
POLYSTYRENE	.030	.04	.96
POLYURETHANE	.003	.05	.95
POLYVINYL CHLORIDE (PVC), “GEON”	.005	.04	.96
LIQUIDS			
WATER	0.003	0.02	0.98
OIL, MINERAL	.040	.03	.97
OIL, ANIMAL OR VEGETABLE	.006	.05	.95
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	0.006	0.02	0.98
CHEMICAL “PYREX”	.001	.06	.94
FUSED QUARTZ	.006	.15	.85

(Continued)

TABLE 6.9 (Continued)

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
METALS, BARE Unoxidized (For oxidized samples of metals, refer to "Composites and Miscellaneous" of Table 6.12.)			
ALUMINUM	Materials in this class are	0.98	0.02
CHROMIUM	opaque (zero transmittance)	.91	.09
COPPER	at any thickness	.98	.02
GOLD		.98	.02
IRON, CARBON STEEL		.95	.05
LEAD		.95	.05
NICKEL		.96	.04
SILVER		.98	.02
STAINLESS STEEL		.87	.13
TIN		.82	.18
ZINC		.98	.02
(GRAPHITE)		.35	.65

FOR ADDITIONAL EMISSIVITY VALUES FOR SERIES 48, SEE TABLE 6.10.

TABLE 6.10

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 48** SPECTRUM: 7.5 to 8.5 microns

All specimens in this table are in their common physical form — e.g. raw materials like coal, gravel, sand, etc. in their normal granular form; construction products like lumber, paneling, tiles, roofing, etc. in their normal delivered forms.

Unless otherwise noted, these materials have negligible Transmittance τ in their common form. Any difference between the listed Emissivity ε and a "perfect" Emissivity of 1.0 is due to Reflectance r.

Materials designated by a "†" symbol have negligible transmittance in bulk form, but thin films of these same materials may be transparent. Emissivity will decrease in proportion to the increase in Transmittance.

TARGET MATERIAL	EMISSIVITY ε
WOOD PRODUCTS	
PAPER, WOOD PULP (0.003" THICK)	0.90
PAPER, BOND STATIONERY (0.003" THICK)	.92*
PAPER, CLAY FILLED (0.012" THICK)	.96
CARDBOARD	.96
WOOD, SOFT OR HARD	.95
HARDBOARD	.95
BUILDING MATERIALS	
ASPHALT, MACADAM	0.98
CLAY, DRY OR WET	.98
CONCRETE, DRY	.94
CONCRETE, WET	.98
CORK	.98
FIBERGLASS BATTS	.98
FORMICA	.92
GLASS	.98
GRAVEL	.98
LINOLEUM	.96
PAINTED METAL	.95
PAINTED WOOD, PLASTIC	.96
PLASTIC PANELS	.96
PLYWOOD	.96
ROCK, CRUSHED	.98
ROOFING, COMPOSITION	.95
RUBBER CLOTH	.96
SAND	.96
TILES, CERAMICS	.98
TILES, RUBBER, PLASTIC	.95
WOOD	.96

TARGET MATERIAL	EMISSIVITY ε
TEXTILES, FABRICS	
CARPET (COTTON, WOOL, SYNTHETIC)	0.98
FABRICS, CLOSE WEAVE (COTTON, WOOL, SYNTHETIC)	.90 - .95
FUR	.96
LEATHER	.96
PLASTICS	.95
FOODS, FOOD PROCESSING	
BAKERY GOODS	0.98
BATTERS	.98
CANDY	.98
CONFECTIONS	.98
DAIRY PRODUCTS	.98
FATS	.98
FRUITS	.98
FLOUR	.98
GRAIN	.98
GRAVIES	.98
JELLIES, JAMS	.98
LIQUIDS	.98
MEATS	.98
OILS	.98
SAUCES	.98
SUGAR	.98
VEGETABLES	.98

(Continued)

TABLE 6.10 (Continued)

TARGET MATERIAL	EMISSIVITY ε
INDUSTRIAL MATERIALS, INORGANIC	
CERAMICS	0.98
CLAY	.98
CHEMICALS, LIQUID OR SOLID	.95
COAL	.98
COKE	.98
FIREBRICK	.98
GLASS	.98
GRAVEL	.98
MINERALS, ORES	.98
SAND	.96
SLAG	.98
STEEL BILLET, OXIDIZED	.82
SLURRIES	.98
WATER,	.98
AQUEOUS SOLUTIONS	.98
INDUSTRIAL MATERIALS, ORGANIC	
CARBON BLACK	0.98
CHEMICALS, LIQUID	.96
CHEMICALS, SOLID	.96
COAL, COKE	.98
OILS, FATS, GREASE †	.96
PETROLEUM PRODUCTS †	.96
PLASTICS †	.96
SOLVENTS †	.96

TARGET MATERIAL	EMISSIVITY ε
COMPOSITES AND MISCELLANEOUS	
CARBON STEEL, OXIDIZED	0.82
DRUGS, PHARMACEUTICALS	.96
FIBERGLASS—EPOXY FORMS	.96
GLASS COATED METAL	.98
NICKEL, OXIDIZED	.85
PAINTED METAL	.90 - .97
PAINTED WOOD	.97
PLASTIC LAMINATED WOOD	.96
PRINTED CIRCUIT BOARDS	.96
RECORDING TAPE	.90
SALT BATH	.96
SANDPAPER	.96
STAINLESS STEEL, OXIDIZED	.85
TOBACCO	.96

† Bulk form. Thin films of these materials may be transparent.

TABLE 6.11

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN IDEALIZED FORM ARRANGED BY CLASSES OF MATERIALS

INSTRUMENT SERIES: **MODLINE 4, Series 43** SPECTRUM: 3.36 to 3.50 microns

All specimens in this table are in the following form:

1. Thick enough to reduce Transmittance τ to less than 0.01.

2. Viewed surface clean, flat, and optically smooth.

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
PLASTICS			
ABS, “CYCOLAC”	0.015	0.03	0.97
ACETAL, “DELRIN”	0.008	0.03	0.97
ACRYLIC, “PLEXIGLAS”, “LUCITE”	0.008	0.03	0.97
CELLULOSICS	0.003	0.03	0.97
CELLOPHANE	0.003	0.03	0.97
EPOXY	0.002	0.03	0.97
POLYAMIDE, “NYLON”	0.005	0.03	0.97
POLYCARBONATE, “LEXAN”	0.015	0.03	0.97
POLYESTER, PET, “MYLAR”, “DACRON”	0.020	0.03	0.97
POLYETHYLENE	0.005	0.03	0.97
POLYPROPYLENE	0.005	0.03	0.97
POLYSTYRENE	0.010	0.03	0.97
POLYVINYL CHLORIDE (PVC), “GEON”	0.010	0.03	0.97
LIQUIDS			
WATER	0.003	0.02	0.98
OIL, MINERAL	0.003	0.03	0.97
OIL, ANIMAL OR VEGETABLE	0.003	0.03	0.97
GLASSES			
SODA-LIME (WINDOWS, BOTTLES)	0.30	0.03	0.97
CHEMICAL “PYREX”	0.12	0.03	0.97

TABLE 6.11 (Continued)

TARGET MATERIAL	MINIMUM THICKNESS (inches)	REFLECTANCE r	EMISSIVITY ε
METALS, BARE Unoxidized (For oxidized samples of metals, refer to "Composites and Miscellaneous" of Table 6.12.)			
ALUMINUM COPPER GOLD	Materials in this class are opaque (zero transmittance) at any thickness.	0.98 0.98 0.98	0.02 0.02 0.02
IRON, CARBON STEEL NICKEL SILVER		0.85 0.93 0.98	0.15 0.07 0.02
STAINLESS STEEL TIN ZINC		0.85 0.69 0.93	0.15 0.31 0.07
(GRAPHITE)		0.38	0.62

FOR ADDITIONAL EMISSIVITY VALUES FOR SERIES 43, SEE TABLE 6.12.

TABLE 6.12

GUIDE TO EMISSIVITY VALUES FOR TARGET MATERIALS IN THEIR "USUAL" FORM ARRANGED BY CLASSES OF MATERIAL

INSTRUMENT SERIES: **MODLINE 4, Series 43** SPECTRUM: 3.36 to 3.50 microns

All specimens in this table are in their common physical form—e.g. raw materials like coal, gravel, sand, etc. in their normal granular form; construction products like lumber, paneling, tiles, roofing, etc. in their normal delivered forms.

Unless otherwise noted, these materials have negligible Transmittance τ in their common form. Any difference between the listed Emissivity ε and a "perfect" Emissivity of 1.0 is due to Reflectance r.

TARGET MATERIAL	EMISSIVITY ε
WOOD PRODUCTS	
PAPER, WOOD PULP (0.003" THICK)	~0.85
PAPER, BOND STATIONERY (0.003" THICK)	~0.85
PAPER, CLAY FILLED (0.012" THICK)	0.75
CARDBOARD	0.92
WOOD, SOFT OR HARD	0.95
HARDBOARD	0.95
BUILDING MATERIALS	
ASPHALT, MACADAM	0.98
CORK	0.98
FIBERGLASS BATTS	0.90
FORMICA	0.95
LINOLEUM	0.96
PAINTED METAL	0.75–0.95
PAINTED WOOD, PLASTIC	0.97
PLASTIC PANELS	0.97
PLYWOOD	0.90
ROOFING, COMPOSITION	0.95
RUBBER CLOTH	0.96
TILES, RUBBER, PLASTIC	0.95

TARGET MATERIAL	EMISSIVITY ε
TEXTILES, FABRICS	
CARPET (COTTON, WOOL, SYNTHETIC)	0.97
FABRICS, CLOSE WEAVE (COTTON, WOOL, SYNTHETIC)	0.80–0.95
FUR	0.96
LEATHER	0.96
PLASTICS	0.97
FOODS, FOOD PROCESSING	
BAKERY GOODS	0.98
BATTERS	0.98
CANDY	0.98
CONFECTIONS	0.98
DAIRY PRODUCTS	0.98
FATS	0.98
FRUITS	0.98
FLOUR	0.98
GRAIN	0.98
GRAVIES	0.98
JELLIES, JAMS	0.98
LIQUIDS	0.97
MEATS	0.98
OILS	0.97
SAUCES	0.98
SUGAR	0.98
VEGETABLES	0.98

(Continued)

TABLE 6.12 (Continued)

TARGET MATERIAL	EMISSIVITY ε
INDUSTRIAL MATERIALS, INORGANIC	
CERAMICS	0.96
CLAY	0.90
CHEMICALS, LIQUID	0.97
CHEMICALS, SOLID	0.80 - 0.95
COAL	0.98
COKE	0.98
FIREBRICK	0.85
GLASS	0.97
GRAVEL	0.95
MINERALS, ORES	0.80 - 0.96
SAND	0.97
SLAG	0.95
STEEL BILLET, OXIDIZED	0.82
SLURRIES	0.98
WATER, AQUEOUS SOLUTIONS	0.98
INDUSTRIAL MATERIALS, ORGANIC	
CARBON BLACK	0.98
CHEMICALS, LIQUID	0.97
CHEMICALS, SOLID	0.80 - 0.96
COAL, COKE	0.98
OILS, FATS, GREASE	0.97
PETROLEUM PRODUCTS	0.97
PLASTICS	0.97
SOLVENTS	0.97
WAXES	0.97

TARGET MATERIAL	EMISSIVITY ε
COMPOSITES AND MISCELLANEOUS	
CARBON STEEL, OXIDIZED	0.82
DRUGS, PHARMACEUTICALS	0.97
FIBERGLASS—EPOXY FORMS	0.97
GLASS COATED METAL	0.97
NICKEL, OXIDIZED	0.85
PAINTED METAL	0.90 - 0.97
PAINTED WOOD	0.97
PLASTIC LAMINATED WOOD	0.97
PRINTED CIRCUIT BOARDS	0.97
RECORDING TAPE	0.85
SALT BATH	0.97
SANDPAPER	0.90
STAINLESS STEEL, OXIDIZED	0.85
TOBACCO	0.97

NEMA SAFETY GUIDELINES FOR THE APPLICATION, INSTALLATION, AND MAINTENANCE OF SOLID STATE CONTROL

Section 1: DEFINITIONS

(This section is classified as NEMA Standard 11-15-1984.)

Electrical Noise—Unwanted electrical energy which has the possibility of producing undesirable effects in the control, its circuits, and system.

Electrical Noise Immunity—The extent to which the control is protected from a stated electrical noise.

Off-State Current—The current that flows in a solid state device in the off-state condition.

Off-State Condition—The conditions of a solid state device where no control signal is applied.

On-State Condition—The condition of a solid state device when conducting.

Surge Current—A current exceeding the steady state current for a short time duration, normally described by its peak amplitude and time duration.

Transient Overvoltage—The peak voltage in excess of steady state voltage for a short time during the transient conditions (e.g., resulting from the operations of a switching device).

Section 2: GENERAL

(Sections 2 through 5 are classified as Authorized Engineering Information 11-15-1984.)

Solid State and electro-mechanical controls can perform similar control functions, but there are certain unique characteristics of solid state controls which must be understood.

In the application, installation and maintenance of solid state control, special consideration should be given to the characteristics described in 2.1 through 2.7.

2.1 AMBIENT TEMPERATURE

Care should be taken not to exceed the ambient temperature range specified by the manufacturer.

2.2 ELECTRICAL NOISE

Performance of solid state controls can be affected by electrical noise. In general, complete systems are designed with a degree of noise immunity. Noise immunity can be determined with tests such as described in 3.4.2. Manufacturer recommended installation practices for reducing the effect of noise should be followed.

2.3 OFF-STATE CURRENT

Solid state controls generally exhibit a small amount of current flow when in the off-state condition. Precautions must be exercised to ensure proper circuit performance and personnel safety. The value of this current is available from the manufacturer.

2.4 POLARITY

Incorrect polarity of applied voltages may damage solid state controls. The correct polarity of solid state controls should be observed.

2.5 RATE OF RISE–VOLTAGE OR CURRENT DV/DT or DI/DT

Solid state controls can be affected by rapid changes of voltage or current if the rate of rise (DV/DT and/or DI/DT) is greater than the maximum permissible value specified by the manufacturer.

2.6 SURGE CURRENT

Current of a value greater than that specified by the manufacturer can affect the solid state control. Current limiting means may be required.

2.7 TRANSIENT OVERVOLTAGE

Solid state controls may be affected by transient over-voltages which are in excess of those specified by the manufacturer. Voltage limiting means should be considered and may be required.

Section 3: APPLICATION GUIDELINES

3.1 GENERAL APPLICATION PRECAUTIONS

3.1.1 Circuit Considerations

The consequences of some malfunctions such as those caused by shorted output devices, alteration, loss of memory, or failure of isolation within components or logic devices require that the user be concerned with the safety of personnel and the protection of the electronics.

It is recommended that circuits which the user considers to be critical to personnel safety, such as "end of travel" circuits and "emergency stop" circuits, should directly control their appropriate functions through an electromechanical device independent of the solid state logic. Such circuits should initiate the stop function through deenergization rather than energization of the control device. This provides a means of circuit control that is independent of system failure.

3.1.2 Power Up/Power Down Considerations

Consideration should be given to system design so that unsafe operation does not occur under these conditions since solid state outputs may operate erratically for a short period of time after applying or removing power.

3.1.3 Redundancy and Monitoring

When solid state devices are being used to control operations, which the user determines to be critical, it is strongly recommended that redundancy and some form of checking be included in the system. Monitoring circuits should check that actual machine or process operation is identical to controller commands; and in the event of failure in the machine, process, or the monitoring system, the monitoring circuits should initiate a safe shutdown sequence.

3.1.4 Overcurrent Protection

To protect triacs and transistors from shorted loads, a closely matched short circuit protective device (SCPD) is often incorporated. These SCPD's should be replaced only with devices recommended by the manufacturer.

3.1.5 Overvoltage Protection

To protect triacs, SCR's and transistors from overvoltages, it may be advisable to consider incorporating peak voltage clamping devices such as varistors, zener diodes, or snubber networks in circuits incorporating these devices.

3.2 CIRCUIT ISOLATION REQUIREMENTS

3.2.1 Separating Voltages

Solid state logic uses low level voltage (e.g., less than 32 volts dc) circuits. In contrast, the inputs and outputs are often high level (e.g., 120 volts ac) voltages. Proper design of the interface protects against an unwanted interaction between the low level and high level circuits; such an interaction can result in a failure of the low voltage circuitry. This is potentially dangerous. An input and output circuitry incorporating effective isolation techniques (which may include limiting impedance or Class 2 supplied circuitry) should be selected.

3.2.2 Isolation Techniques

The most important function of isolation components is to separate high level circuits from low level circuits in order to protect against the transfer of a fault from one level to the other.

Isolation transformers, pulse transformers, reed relays, or optical couplers are typical means to transmit low level logic signals to power devices in the high level circuit. Isolation impedance means also are used to transmit logic signals to power devices.

3.3 SPECIAL APPLICATION CONSIDERATIONS

3.3.1 Converting Ladder Diagrams

Converting a ladder diagram originally designed for electromechanical systems to one using solid state control must account for the differences between electromechanical and solid state devices. Simply replacing each contact in the ladder diagram with a corresponding solid state "contact" will not always produce the desired logic functions or fault detection and response. For example, in electromechanical systems, a relay having a mechanically linked normally open (NO) and normally closed (NC) contact can be wired to check itself. Solid state components do not have a mutually exclusive NO-NC arrangement. However, external circuitry can be employed to sample the input and "contact" state and compare to determine if the system is functioning properly.

3.3.2 Polarity and Phase Sequence

Input power and control signals should be applied with polarity and phase sequence as specified by the manufacturer. Solid state devices can be damaged by the application of reverse polarity or incorrect phase sequence.

3.4 PLANNING ELECTRICAL NOISE - REJECTION

The low energy levels of solid state controls may cause them to be vulnerable to electrical noise. This should be considered in the planning stages.

3.4.1 Assessing Electrical Environment

Sources of noise are those pieces of equipment that have large, fast changing voltages or currents when they are energized or de-energized, such as motor starters, welding equipment, SCR type, adjustable speed devices, and other inductive devices. These devices, as well as the more common control relays and their associated wiring, all have the capability of inducing serious current and voltage transients on their respective power lines. It is these transients which nearby solid state controls must withstand and for which noise immunity should be provided.

An examination of the proposed installation site of the solid state control should identify equipment that could contaminate power lines. All power lines that will be tapped by the proposed solid state control should be examined for the presence, severity, and frequency of noise occurrences. If found, system plans should provide for the control of such noise.

3.4.2 Selecting Devices to Provide Noise Immunity

Installation planning is not complete without examination of the noise immunity characteristics of the system devices under consideration. Results of tests to determine relative immunity to electrical noise may be required from the manufacturer. Two such standardized tests are the ANSI (C37.90a-1974) *Surge Withstand Capability Test* and the NEMA (ICS 1-1983) noise test referred to as *The Showering Arc Test.* These are applied where direct connection of solid state control to other electromechanical control circuits is intended. Circuits involving analog regulating systems or high speed logic are generally more sensitive to electrical noise; therefore, isolation and separation of these circuits is more critical.

Further information on electrical noise and evaluation of the severity of noise may be found in ANSI/IEEE Publication No. 518-1982.

Where severe power line transients are anticipated or noted, appropriate filters such as commercially available line filter, isolation transformers, or voltage limiting varistors, should be considered.

All inductive components associated with the system should be examined for the need for noise suppression.

3.4.3 Design of Wiring for Maximum Protection

Once the installation site and power conductors have been examined, the system wiring plans that will provide noise suppression should be considered.

Conducted noise enters solid state control at the points where the control is connected to input lines, output lines, and power supply wires.

Input circuits are the circuits most vulnerable to noise. Noise may be introduced capacitatively through wire to wire proximity or magnetically from nearby lines carrying large currents. In most installations, signal lines and power lines should be separate. Further, signal lines should be appropriately routed and shielded according to the manufacturer's recommendations.

When planning system layout, care must be given to appropriate grounding practice. Because design differences may call for different grounding, the control manufacturer's recommendations should be followed.

3.5 COUNTERING THE EFFECTS OF OFF-STATE CURRENT

3.5.1 Off-State Current

Solid state components, such as triacs, transistors, and thyristors, inherently have in the off-state a small current flow called "off-state current".

Off-state current may also be contributed by devices used to protect these components, such as RC snubbers.

3.5.2 Off-State Current Precautions

Off-state currents in a device in the off-state may present a hazard of electrical shock and the device should be disconnected from the power source before working on the circuit or load.

Appendix

Precautions should be taken to prevent the off-state current of an output device which is in the off-state from energizing an input device.

3.6 AVOIDING ADVERSE ENVIRONMENTAL CONDITIONS

3.6.1 Temperature

Solid state devices should only be operated within the temperature ranges specified by the manufacturer. Because such devices generate heat, care should be taken to see that the ambient temperature at the device does not exceed the temperature range specified by the manufacturer.

The main source of heat in a solid state system is the energy dissipated in the power devices. Since the life of the equipment can be increased by reducing operating temperature, it is important to observe the manufacturer's "maximum/minimum ambient temperature" guidelines, where ambient refers to the temperature of the air providing the cooling. The solid state equipment must be allowed to stabilize to within the manufacturer's recommended operating temperature range before energizing control functions.

When evaluating a system design, other sources of heat in the enclosure which might raise the ambient temperature should not be overlooked. For example, power supplies, transformers, radiated heat, sunlight, furnaces, incandescent lamps, and so forth should be evaluated.

In instances where a system will have to exist in a very hot ambient environment, special cooling methods may have to be employed. Techniques that are employed include cooling fans (with adequate filtering), vortex coolers, heat exchanges, and air conditioned rooms.

Over-temperature sensors are recommended for systems where special cooling is employed. Use of air conditioning should include means for prevention of condensing moisture.

3.6.2 Contaminants

Moisture, corrosive gases and liquids, and conductive dust can all have adverse effects on a system that is not adequately protected against atmospheric contaminants.

If these contaminants are allowed to collect on printed circuit boards, bridging between the conductors may result in malfunction of the circuit. This could lead to noisy, erratic control operation or, at worst, a permanent malfunction. A thick coating of dust could also prevent adequate cooling on the board or heat sink, causing malfunction. A dust coating on heat sinks reduces their thermal efficiency.

Preventive measures include a specially conditioned room or a properly specified enclosure for the system.

3.6.3 Shock and Vibration

Excessive shock or vibration may cause damage to solid state equipment. Special mounting provisions may be required to minimize damage.

3.7 THE NEED FOR SAFETY–KNOWLEDGE LEADS TO SAFETY

Planning for an effective solid state circuit requires enough knowledge to make basic decisions that will render the system safe as well as effective.

Everyone who works with a solid state control should be educated in its capabilities and limitations. This includes in-plant installers, operators, service personnel, and system designers.

Section 4: APPLICATION GUIDELINES

4.1 INSTALLATION AND WIRING PRACTICE

4.1.1 Proper installation and field wiring practices are of prime importance to the application of solid state controls. Proper wiring practice will minimize the influence of electrical noise, which may cause malfunction of equipment.

Users and installers should familiarize themselves with and follow installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards. The manufacturer of the device or component in question should be consulted whenever conditions arise that are not covered by the manufacturer's instructions.

4.1.2 Electrical noise is a very important consideration in any installation of solid state control. While wiring practices may vary from situation to situation, the following are basic to minimizing electrical noise:

1. Sufficient physical separation should be maintained between electrical noise sources and sensitive equipment to assure that the noise will not cause malfunctioning or unintended actuation of the control.
2. Physical separation should be maintained between sensitive signal wires and electrical power and control conductors. This separation can be accomplished by conduits, wiring trays, or as otherwise recommended by the manufacturer.
3. Twisted-pair wiring should be used in critical signal circuits and noise producing circuits to minimize magnetic interference.
4. Shielded wire should be used to reduce the magnitude of the noise coupled into the low level signal circuit by electrostatic or magnetic coupling.
5. Provisions of the 1984 *National Electrical Code* with respect to grounding should be followed. Additional grounding precautions may be required to minimize electrical noise. These precautions generally deal with ground loop currents arising from multiple ground paths. The manufacturer's recommendations should be followed.

4.2 ENCLOSURES (COOLING AND VENTILATING)

Suitable enclosures and control of the maximum operating temperature, both of which are environmental variables, may be needed to prevent malfunction of solid state control.

The manufacturer's recommendations should be followed for the selection of enclosures, ventilation, air filtering (if required), and ambient temperature. These recommendations may vary from installation to installation, even within the same facility.

4.3 SPECIAL HANDLING OF ELECTROSTATIC SENSITIVE DEVICES

Some devices may be damaged by electrostatic charges. These devices are identified and should be handled in the special manner specified by the manufacturer.

NOTE: Plastic wrapping materials used to ship these devices may be conductive and should not be used as insulating material.

4.4 COMPATIBILITY OF DEVICES WITH APPLIED VOLTAGES AND FREQUENCIES

Prior to energization, users and installers should verify that the applied voltage and frequency agree with the rated voltage and frequency specified by the manufacturer.

NOTE: Incorrect voltage or frequency may cause a malfunction of, or damage to, the control.

4.5 TESTING PRECAUTIONS

When testing solid state control, the procedures and recommendations set forth by the manufacturer should be followed.

When applicable, instrumentation and test equipment should be electrically equivalent to that recommended by the manufacturer for the test procedure. A low impedance voltage tester should not be used.

High voltage insulation tests and dielectric tests should never be used to test solid state devices. If high voltage insulation of field wiring is required, solid state devices should be disconnected. Ohmmeters should only be used when and as recommended by the equipment manufacturer.

Testing equipment should be grounded; if it is not, special precautions should be taken.

4.6 STARTUP PROCEDURES

Checks and tests prior to startup and startup procedures recommended by the manufacturer should be followed.

Section 5: PREVENTIVE MAINTENANCE AND REPAIR GUIDELINES

5.1 GENERAL

A well-planned and -executed maintenance program is essential to the satisfactory operation of solid state electrical equipment. The kind and frequency of the maintenance operation will vary with the kind and complexity of the equipment as well as with the nature of the operating conditions. Maintenance recommendations of the manufacturer or appropriate product standards should be followed.

Useful reference publications for setting up a maintenance program are NFPA 70B-1983, *Maintenance of Electrical Equipment*, and NFPA 70E-1983, *Electrical Safety Requirements for Employee Workplaces.*

5.2 PREVENTIVE MAINTENANCE

The following factors should be considered when formulating a maintenance program:

1. Maintenance must be performed by qualified personnel familiar with the construction, operation, and hazards involved with the control.
2. Maintenance should be performed with the control out of operation and disconnected from all sources of power. If maintenance must be performed while the control is energized, the safety related practices of NFPA 70E should be followed.
3. Care should be taken when servicing electrostatic sensitive components. The manufacturer's recommendations for these components should be followed.
4. Ventilation passages should be kept open. If the equipment depends upon auxiliary cooling, e.g., air, water, or oil, periodic inspection (with filter replacement when necessary) should be made of these systems.
5. The means employed for grounding or insulating the equipment from ground should be checked to assure its integrity (see 4.5).
6. Accumulations of dust and dirt on all parts, including on semiconductor heat sinks, should be removed according to the manufacturer's instructions, if provided; otherwise, the manufacturer should be consulted. Care must be taken to avoid damaging any delicate components and to avoid displacing dust, dirt, or debris in a way that permits it to enter or settle into parts of the control equipment.
7. Enclosures should be inspected for evidence of deterioration. Accumulated dust and dirt should be removed from the top of the enclosures before opening doors or removing covers.
8. Certain hazardous materials removed as part of maintenance or repair procedure (e.g., polychlorinated biphenyls (PCB) found in some liquid filled capacitors) must be disposed of as described in Federal regulations.

5.3 REPAIR

If equipment condition indicates repair or replacement, the manufacturer's instruction manual should be followed carefully. Diagnostic information within such a manual should be used to identify the probable source of the problem, and to formulate a repair plan. The level of field repair recommended by the manufacturer should be followed.

When solid state equipment is repaired, it is important that any replacement part be in accordance with the recommendations of the equipment manufacturer. Care should be taken to avoid the use of parts which are no longer compatible with other changes in the equipment. Also, replacement parts should be inspected for deterioration due to "shelf life" and for signs of rework or wear which may involve factors critical to safety.

After repair, proper start-up procedures should be followed. Special precautions should be taken to protect personnel from hazards during start-up.

5.4 SAFETY RECOMMENDATIONS FOR MAINTENANCE PERSONNEL

All maintenance work should be done by qualified personnel familiar with the construction, operation, and hazards involved with the equipment. The appropriate work practices of NFPA 70E should be followed.

DISASSEMBLY INSTRUCTIONS FOR DISPOSAL AND RECYCLING:
IRCON MODLINE 4 PRODUCT AND ACCESSORIES

Following are the disassembly instructions for the Ircon Modline 4 product, including all optional accessories, in accordance to guidelines of the European Union Waste Electric and Electronic Equipment (WEEE) Directive 2002/96/EC.

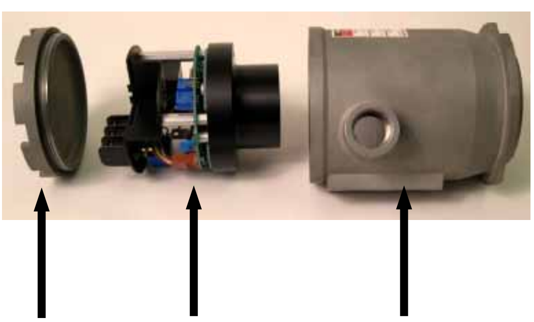
This product includes the following materials to be dispensed of properly:

Aluminum	Standard Sensor Casing Body and Lid, Spacers
Brass	Cooling Jacket Body and Lid
Plastic	Lens Housing
Steel	Screws, Brackets within Lens Housing
Printed Circuit Board	Within Modline 4 Sensor Assembly
Rubber	Gaskets

Fully Assembled View:
At right is a photograph of a fully-assembled Ircon Modline 4 sensor with standard casing. Disassembly instructions for the Modline 4 sensor with Standard casing, and with the Cooling Jacket accessory is shown on the following pages. These instructions account for all Modline 4 models, as the variation between models affecting recycling is minimal.

1

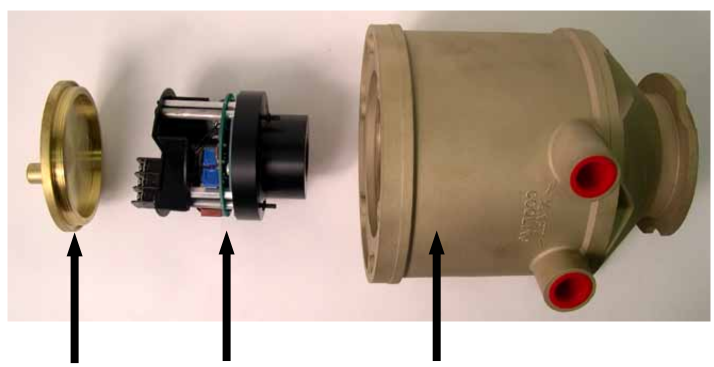
Modline 4 – with Standard Casing



3

2

Modline 4 – with Cooling Jacket

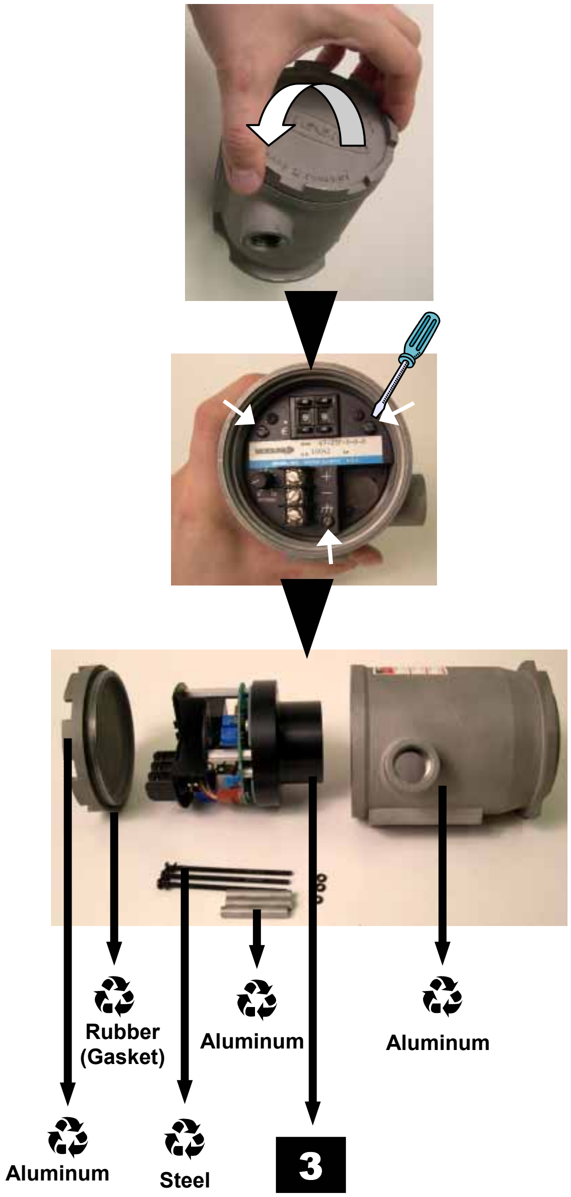


3

DISASSEMBLY INSTRUCTIONS FOR DISPOSAL AND RECYCLING:
IRCON MODLINE 4 PRODUCT AND ACCESSORIES

1

Modline 4 – with Standard Casing



2

Modline 4 – with Cooling Jacket

DISASSEMBLY INSTRUCTIONS FOR DISPOSAL AND RECYCLING:
IRCON MODLINE 4 PRODUCT AND ACCESSORIES