R40 SERIES

FIXED INFRARED SENSORS

USER MANUAL

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Table of Contents

Heat Spy Warranty 4
Safety Instructions 5
Acceptable Operation 5
Unacceptable Operation 5
Instrument Disposal 5
Laser Warning 5
110 / 230 V Power Supply 5
R40 Product Line 7
Principle of Operation 9
Basics of Infrared Thermometry 9
Detector 9
Thermopile 9
Photodiode 9
Lens and Filter 10
Target Ratio 10
Maximum Distance and Spot Size 10
Proper Placement of Sensor 10
R40: Optics Diagrams 11
Air Purity 12
Installation 12
Ambient Temperature 12
R40 Air/Water Cooling Jacket 12
Environment 13
Electrical Interference 13
Mechanical Installation 13
Cable Connection 14
Power Supply 15
R40 Series Operation and Menu 16
Control Panel 16
Output 17

Milliamp Output 17
Relay Output 17
Input 17
Signal Processing 17
Average 18
..... 18
Peak 19
Valley 19
Peak-Picker 19
Peak-Picker with reset 20
Peak-Picker delayed 20
Valley-Picker 21
Valley-Picker with reset 21
Track and Hold 21
R Series Communication Protocol 22
Temperature Measuring Unit (TMU) Protocol 22
Accessories Guide 25
Surface Mount Bracket 25
Wall Mount Flange 26
Air Purge 26
Protective Window for R40 units 27
R40 Cooling Jacket 28
Sighting Tube 29
Cable 29
Industrial Power Supply 30
Emissivity 31
Typical Emissivity Values 32
Maintenance and Troubleshooting 32
Purge Air Supply 33
Water Supply 33
Optic Cleaning 33

Mounting Device 33
Interconnection Cable 33
Error Codes 34
Return for Calibration Service 34
Appendix I: Emissivity of Common Materials 35
Hints for Choosing and Using 35
Know your target 35
Know your spot size 35
Have realistic expectations 35
How It Works 35
Emissivity Table 37

Thank you for purchasing a Wahl High Performance Fixed Infrared Thermometer.
We appreciate your business.

Heat Spy Warranty

Manufacturer warrants all Wahl Heat Spy Fixed Infrareds manufactured by us to be free from defects in material or workmanship under normal use and service. The Manufacturer agrees to repair or replace any product listed above which upon examination is revealed to have been defective due to faulty workmanship or material if returned to our factory, transportation charges prepaid, within the product specific warranty period of two (2) years from date of purchase. This warranty is in lieu of all other warranties, expressed or implied and of all obligations or liabilities on its part for damages including but not limited to normal wear and tear or consequential damages following the use or misuse of this or any instrument sold by the Manufacturer. In addition, if the product is tampered with in any way or calibrated in any way other than by the instructions supplied by Palmer Wahl, it will immediately void the warranty. No agent is authorized to assume, for the manufacturer, any liability except as set forth above. Freight cost to return item(s) for evaluation, duties and other fees are not covered by the manufacturer.

Product is automatically registered for warranty by serial number at time of purchase. Serial number must remain attached to product upon return.

Safety Instructions

This document contains important information and should be kept with the instrument at all times during its operational life. Other users of this instrument should be given these instructions with the instrument. Future updates to this information can be found at www.wahlheatspy.com and must be added to the original document. The instrument can only be operated by trained personnel in accordance with these instructions and local safety regulations.

Acceptable Operation

This instrument is intended only for the measurement of temperature. The instrument is appropriate for continuous use and operates reliably in demanding conditions, such as in high environmental temperatures, as long as the documented technical specifications for all instrument components are adhered to. Compliance with the operating instructions is necessary to ensure the expected results.

Unacceptable Operation

This instrument should not be used for medical diagnosis.
Replacement Parts and Accessories: Use only original parts and accessories approved by the manufacturer. The use of other products can compromise the operation safety and functionality of the instrument.

Instrument Disposal

Disposal of old instruments should be handled according to professional and environmental regulations of your area for electronic waste.

Laser Warning

The instrument could be equipped with a Class 2 laser. Class 2 lasers shine only within a visible area at an intensity of 1 mW. The laser functions only to locate and mark surface measurement targets. **Do not aim the laser at people or animals.**
DO NOT AIM THE LASER AT THE EYE AS EYE DAMAGE WILL RESULT.

110 / 230 V Power Supply

Use in 110 / 230 V electrical systems can result in electrical hazards and personal injury if not properly protected. All instrument parts supplied by electricity must be covered to prevent physical contact and other hazards at all times.

R40 Specifications

R40 Series Specifications

High Performance Fixed Infrared Sensor				
MEASURING SPECIFICATIONS	**Model Numbers**	**1M / 2M**	**3M**	**MT / F4 / G5 / G7 / P3[4] / P7 / LT**
	Accuracy [1]	± (0.25% of reading + 1°C)	± (0.1% of reading + 3°C)	± 0.6% of reading or ± 1°C, whichever is higher
	Repeatability [2]	± 0.10% of reading or ± 1°C, whichever is greater		± 0.3% of reading or ± 0.3°C, whichever is greater
	LCD Resolution	1°F / 1°C		1°F / 1°C
	Response Time [3]	5 mS		150 mS
	Emissivity	0.10 to 1.00		0.10 to 1.00
ELECTRONIC SPECIFICATIONS	**Display**	LCD, 5-digit, 1° Resolution		
	Keyboard	4 - Key		
	Analog Output	0-20mA, 4-20mA		
	Digital Output	RS485		
	Alarm	High or Low		
	Signal Processing	AVG / PEAK HOLD / VALLEY HOLD		
	Relay	User Programmable		
	Cable	12-pin Connection Cable		
	Power Supply	24 VDC Nominal, (10 - 32 VDC)		
SENSOR SPECIFICATIONS	**Ambient Temperature**	0° to 65°C, (32° to 149°F)		
		With Air Cooling: 0° to 120°C, (32° to 250°F)		
		With Water Cooling: 0° to 175°C, (32° to 350°F)		
	Storage Temperature	-20° to 70°C (-4° to 158°F)		
	Relative Humidity	10% to 95% non-condensing		
ENCLOSURE	**Protection Class**	IP65 (NEMA-4)		
	Laser Sight	650 nm <1mW, Class II		
	Housing Material	ANSI 304 Stainless Steel		
	Housing Dimensions / Weight	1.77 x 7.20 in (45mm Dia. x 183mm) / 1.58 lbs (0.72 kg)		

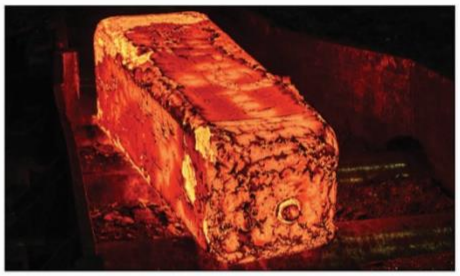
1 at ambient temperature 23°C, ε =1.0, NIST transfer standard.
2 at ambient temperature 23°C.
3 90% of value.
4 after 20 minute warm-up.

The Wahl R40 conforms to RoHS requirements according to EU Directive (EU) 2015/863 amending Annex II to Directive 2011/65/EU for restriction of Hazardous substances.

R40 Product Line

R40 Series Models and Applications

Model Code	Type	Spectral Range	Temperature Span	Application
Molten, Hot and Cold Metal Applications				
1M	Ferrous Metal	1.0µm	600° to 3000°C (1112° to 5432°F)	Ferrous Metal Molten Glass Molten Metal Molten Ceramics Hot Graphite
2M	Hot Metal, Hot Ceramic	1.6µm	400° to 2300°C, (752° to 4172°F)	Hot Metal Hot Ceramic
3M	Cold Ferrous Metal	2.4µm	50° to 1600°C (122° to 2912°F)	Cold Ferrous Metal Iron, Steel and Steel Alloy



Model 3M is used for Iron, Steel and Steel Alloy.
It is not for use with Aluminum, Brass, Bronze, Copper, Lead, Nickel, Titanium and Zinc.

Model Code	Type	Spectral Range	Temperature Span	Application
Heating and Furnace Applications				
MT	Thru Flame	3.9µm	600° to 1500°C (1112° to 2732°F)	Thru hot furnace gases and clean burning gas flames, indicates correct temperatures of substances during warm up process in industrial furnaces
F4	Burning Gas	4.11 - 4.72µm	400° to 1600°C (752° to 2912°F)	CO_2 Gas (4.24 Micron) in Chimney NO_2 Gas (4.55 Micron) in Combustion Hot CO Gas (4.66 Micron) in Combustion Flame Temperature in Boiler / Furnace Utility Power Station Biomass Boilers Furnaces Garbage Incinerators Hazardous Waste Kilns

R40 Series Models and Applications

Model Code	Type	Spectral Range	Temperature Span	Application
Glass Applications				
G5	Thick Glass	5.0µm	400° to 2250°C (752° to 4082°F)	Glass above 1 mm thickness Flat Glass Production Glass Bending Automobile Glass Assembly
G7	Thin Glass	7.9µm	40° to 1000°C (104° to 1832°F)	Thin Glass Below 1 mm thickness Light Bulb Production Medical Vial Production

Model Code	Type	Spectral Range	Temperature Span	Application
Plastics Applications				
P3	Thin Film Plastics	3.43µm	100° to 500°C (212 °to 932°F)	Plastic Thin Film (1 to 3 mil), Polyethylene Films and all types of fluorocarbon-plastics Polyethylene (PE) Polypropylene (PP) Polyamide (Nylon) Polystyrene (PS) Polyvinyl Chloride (PVC) Polyurethane Vinyl / Acrylic / Polycarbonate Cellophane
P7	Thin Film Plastics	7.9µm	40° to 600°C (104° to 1112°F)	Plastic Thin Film, (1 to 3 mil) Polyester Films and all types of fluorocarbon-plastics Polyester Cellulose Acetate Polyurethane Teflon (Fluoroplastic FEP) Polyvinyl Chloride (PVC) Acrylic / Polycarbonate Polyamide (Nylon) Polyester (>10 µm)

Model Code	Type	Spectral Range	Temperature Span	Application
Low Temperature Applications				
LT	Low Temp	8 to 14µm	-20° to 800°C (-4° to 1472°F)	Organic Materials Baking Production Painted Metal Surfaces Rubber, Tires Paper Textiles Thicker Plastics

Principle of Operation

R Series Fixed-IR sensors use a modular structure and component interchangeability to ensure an instrument is ideally suited for each particular application. It also simplifies field troubleshooting, repair and calibration.

Basics of Infrared Thermometry

Every object emits some amount of infrared radiation. As the object temperature increases, the intensity of the radiated energy increases. This emitted energy is related to a term called emissivity which is a number between 0 and 1 which is the object emitted energy in relation to a black body perfect radiator. A perfect radiator has an emissivity of 1 meaning that all the energy being emitted belongs to it whereas the measured target of interest may have part of its emitted energy being reflected from something else. We want to factor out the reflected energy by selecting a correct emissivity setting. The emissivity of most common materials is known, either exactly or closely as some objects will vary due to age and cleanliness. See more information about emissivity and a table of values for common materials in Appendix I.

Detector

Thermopile

A thermopile is a tight cluster of a large number of tiny specialized thermocouples. They are connected together to form a single measuring point and the output is the difference between the ambient temperature the head electronics are in (the cold junction) and the target temperature collected and determined by the optical system wavelength filter and the thermopile (hot junction).

The waveband is determined by an additional optical filter chosen by the manufacturer for the specific application. This is to reduce or eliminate emitted wavelengths, which might belong to the target or might be unwanted reflections that are of no interest for the measurement application.

Wahl provides six (6) different spectrums in our thermopile versions. They are 3.43 micron, 3.9 micron, 4.11 to 4.72 micron, 5.0 micron, 7.9 micron and 8 to 14 micron.

Photodiode

Both Silicon and InGaAs photodiode principles are completely different from thermopile: the collected energy is transformed into electron flow. The result is a current proportional with the incident energy.

This transformation is very fast, taking only a few µS. The response time of the measuring system is limited by the electronics; high resolution and low energy consumption makes it a little bit slower. The waveband is determined by the physical characteristic of the sensor.

Wahl provides three (3) different spectrums in our photodiode versions, The R40 has all three options: 1.0 micron, 1.6 micron and 2.4 micron.

Lens and Filter

The specifications of the lens decisively determine the optical path of the infrared thermometer, characterized by the ratio Distance to Spot size. The spectral filter selects the wavelength range, which is relevant for the temperature measurement. The detector and the processing electronics transform the emitted infrared radiation into electrical signals.

Target Ratio

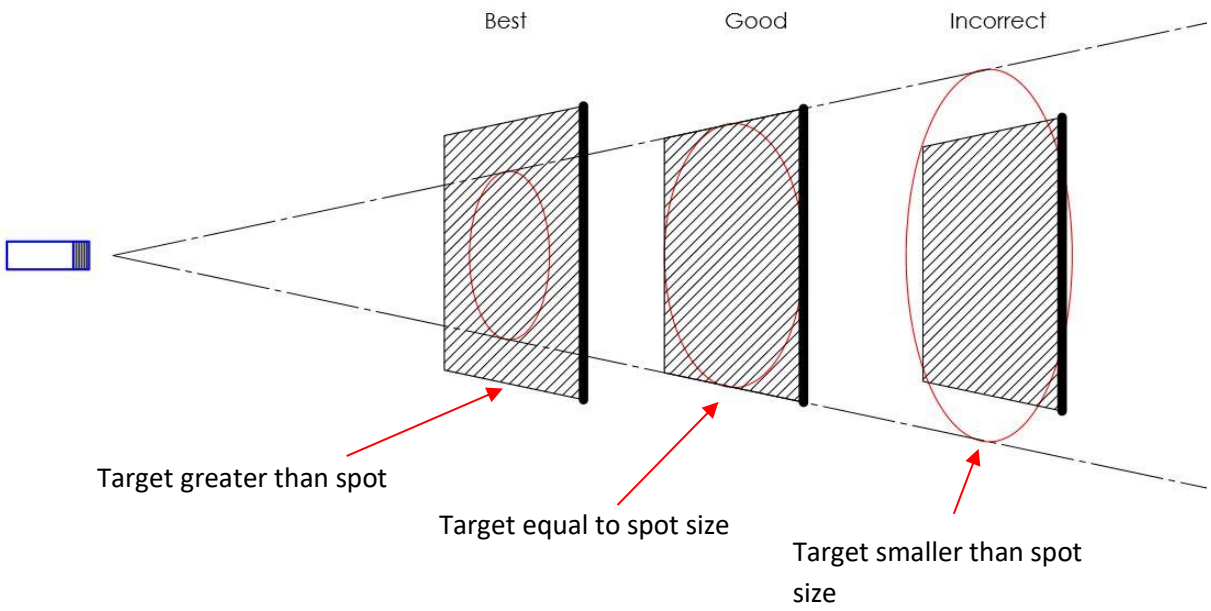
The actual area being measured is determined by the distance-to-spot ratio of the model you are using; this varies from model to model. As the distance from the object being measured increases, the spot size of the area being measured also increases.

Wahl provides four (4) optics options for the R40 model for both the photodiode and thermopile versions.

Maximum Distance and Spot Size

Use the size of the object being measured, together with the optical resolution of the infrared thermometer to determine the maximum distance between the two. The object being measured should completely fill the field of view of the optics to prevent any potential errors.

Proper Placement of Sensor



To achieve the best results, the spot size of the infrared thermometer should be smaller than the object being measured.

Before installation, review the target to ratio tables on the following pages for the appropriate Optics image for your model to determine the correct distance and visual field.

R40: Optics Diagrams

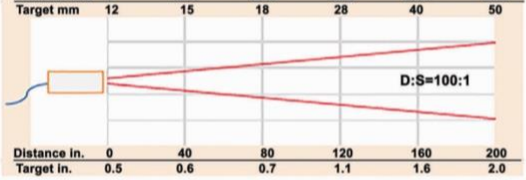
R40 Series Optics Diagrams

Photodiode Models

1M / 2M / 3M OPTICS

Optics Code: D100

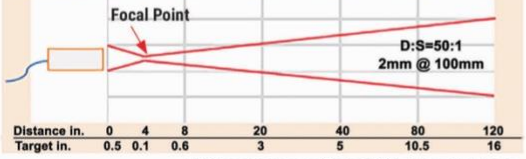
Distance mm	0	1000	2000	3000	4000	5000
Target mm	12	15	18	28	40	50



Distance in.	0	40	80	120	160	200
Target in.	0.5	0.6	0.7	1.1	1.6	2.0

Optics Code: F100

Distance mm	0	100	200	500	1000	2000	3000
Target mm	12	2	16	58	128	268	408

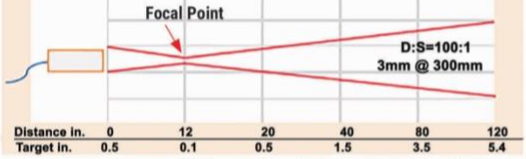


Distance in.	0	4	8	20	40	80	120
Target in.	0.5	0.1	0.6	3	5	10.5	16

F100 has a Distance to Spot of 50:1, at Focal Point only.

Optics Code: F300

Distance mm	0	300	500	1000	2000	3000
Target mm	12	3	13	38	88	138

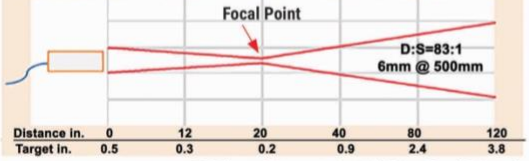


Distance in.	0	12	20	40	80	120
Target in.	0.5	0.1	0.5	1.5	3.5	5.4

F300 has a Distance to Spot of 100:1, at Focal Point only.

Optics Code: F500

Distance mm	0	300	500	1000	2000	3000
Target mm	12	8	6	24	60	96



Distance in.	0	12	20	40	80	120
Target in.	0.5	0.3	0.2	0.9	2.4	3.8

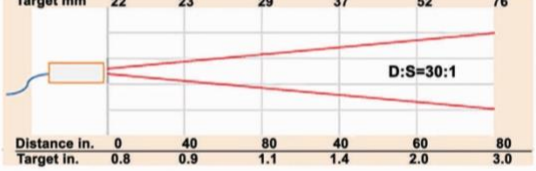
F500 has a Distance to Spot of 83:1, at Focal Point only.

Thermopile Models

P3 / MT / F4 / G5 / P7 / G7 / LT OPTICS

Optics Code: D30

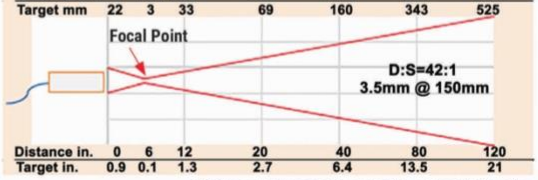
Distance mm	0	300	500	1000	1500	2000
Target mm	22	23	29	37	52	76



Distance in.	0	40	80	40	60	80
Target in.	0.8	0.9	1.1	1.4	2.0	3.0

Optics Code: F150

Distance mm	0	150	300	500	1000	2000	3000
Target mm	22	3	33	69	160	343	525

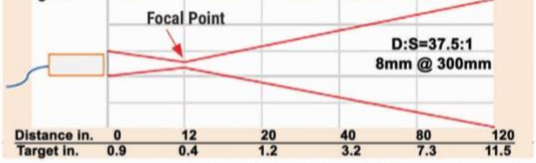


Distance in.	0	6	12	20	40	80	120
Target in.	0.9	0.1	1.3	2.7	6.4	13.5	21

F150 has a Distance to Spot of 42:1, at Focal Point only.

Optics Code: F300

Distance mm	0	300	500	1000	2000	3000
Target mm	22	9	30	82	185	288

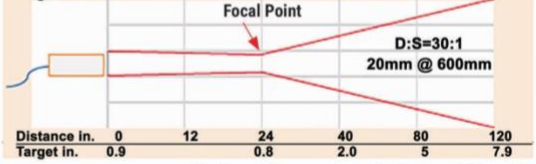


Distance in.	0	12	20	40	80	120
Target in.	0.9	0.4	1.2	3.2	7.3	11.5

F300 has a Distance to Spot of 37.5:1, at Focal Point only.

Optics Code: F600

Distance mm	0	300	600	1000	2000	3000
Target mm	22		21	50	121	193



Distance in.	0	12	24	40	80	120
Target in.	0.9		0.8	2.0	5	7.9

F600 has a Distance to Spot of 30:1, at Focal Point only.

Air Purity

The lens must always be kept clean from:

- Dust
- Dirt
- Steam
- Vapors
- Fumes
- Particles
- Other contaminants

The flowing air from the Air Purge Collar, available as an accessory, can also be used to:

- Blow Smoke away from the lens
- Blow air out around the lens to counteract incoming waves of “Heat” from very hot process fluctuations. This is necessary to prevent coating or covering of the surface of the lens which will cause reading errors and might cause lens damage. It is important to make sure that only oil-free, dry, and clean filtered instrument grade compressed air is used.

Installation

R Series Fixed IR installation is very easy. The cylindrical stainless steel is externally threaded (M44 x 1.5) and allows quick connection with all available accessories.

Use the following procedure to install the R Series Fixed IR.

Ambient Temperature

R40 - Do not mount the measuring head in a room with an ambient temperature higher than 149°F (65°C) without an adequate cooling system.

a) The sensor is designed for measurements in ambient temperatures between 32° to 149°F (0°C to 65°C).
b) In ambient conditions above 149°F (65°C), the operating range can be extended to 250°F (120°C) with air cooling and to 350°F (175°C) with water cooling.
c) In ambient conditions up to 600°F (315°C), a heavy-duty housing should be used.
d) When using the water-cooled housing, it is strongly recommended to use the supplied air purge collar to avoid condensation on the lens.

R40 Air/Water Cooling Jacket

When installing the R40 instrument head in a hot environment it is necessary to cool its electronics by pumping cold air or water through the cooling jacket. Use only clean air or water to prevent build-up which might cause an obstruction inside the unit or at its outlet. The air or water must be cold enough and of sufficient volume to cool the electronics for the ambient environment.
Before running the water line please follow the following precautions:

1) The outlet of the cooling jacket must be kept clean in order to control the flow and water temperature;
2) Use a thermometer to control the water temperature.

NOTE: IN CLOSED CIRCUIT SYSTEMS, ALWAYS USE RUNNING WATER WITH A LOW-LEVEL PRESSURE GAUGE TO ASSURE THE CONTINUOUS SUPPLY OF WATER.

Environment

The environmental conditions at the installation point of the unit can have a significant impact on its performance. Avoid mounting the unit in locations near reflective surfaces or items that are very hot or cold. Bothersome reflections may affect your emissivity settings which will affect your target temperature readings. Ideally, your target areas should be, as far as possible, isolated from outside influences. Within the target area, everything should be as stable and repeatable as possible.

Electrical Interference

Do not route the signal cable near electromagnetic sources (for example: electrical motors, high power cables, welding, etc.). If necessary, use metal conduit.

Do not pull out the electronic board from the cylinder; it could be difficult to reassemble the thermometer.

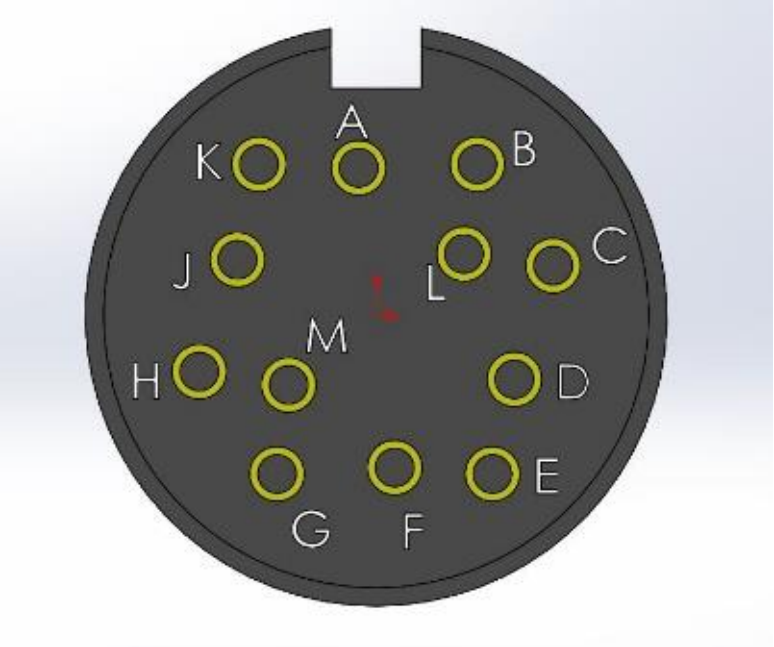
To shield the connection cables, extend the shield wire to the destination point (display, controller, etc.) and connect it to ground.

Mechanical Installation

Using the Target vs. Distance Tables for Model R40 for the appropriate Optics image for your model, accurately aim the thermometer at the target. The optional laser aiming can assist you in achieving the best installation.

Cable Connection

12 pin cable definition



PIN	R40
G	24V DC
L	24V GND
C	485 A
E	Unused
D	485 B
F	Unused
J	mA (-)
B	mA (+)
K	Relay NO/NC
A	Relay COM
H	Trigger
M	Shield

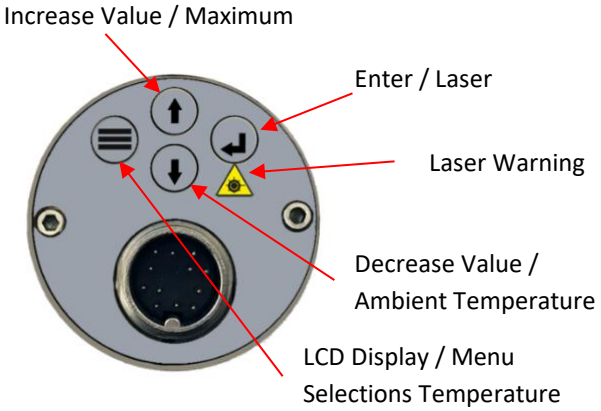
Note: Each wire is labeled individually with its purpose.

Power Supply

A power supply is built-into the thermometer for adapting the current loop supply from 12 to 32 VDC to all digital and analog circuits.

R40 Series Operation and Menu

Control Panel



1) Quick Keys Layout
2) Power on to enter MENU 0 (Real-Time Temperature)
3) MENU key to scroll MENU 01 – 14
4) MENU 01 is Measuring Mode
5) MENU 02-14 is Editing Mode
6) MENU 00 is Reading Mode
7) Key Definition

		Measuring Mode	Editing Mode
	Mode Switch	In Editing Mode, press ▼ until Menu no.14, then return to Measuring Mode	In Measuring Mode, press ▼ to enter Editing Mode by Menu below.
◄	MENU	Menu Loop	Save and go to next menu Select second level menu
►	ENTER	Laser	Scroll between digits
▲	UP	Maximum Temperature	Increase Value
▼	DOWN	Ambient Temperature	Decrease Value

8) Menu

	Parameter	Code	Display	Range	Default
0	Object Temperature	-	925C		
1	Emissivity	E	E 0.99	0.10 to 1.00	1.00
2	Transmission	T	T 1.00	0.10 to 1.00	1.00
3	Average / Peak / Valley Select	A		A = Average P = Peak V = Valley	
4	Average / Peak / Valley Time Setting			0 to 999 seconds 0 = consistently off 999 = consistently on	
5	Analog Output Select		4-20	0-20 / 4-20	4-20
6	0/4 mA Temperature Setting	⌣	u 600	Minimum Range: 100C	Range Low
7	20mA Temperature Setting	⌒	n 1300		Range High
8	Laser Switch		0	1=on / 0=off	1
9	Low Temperature Alarm	L			L 600
10	High Temperature Alarm	H		Setting	H1300
11	Multiple Sensor ID	ID	ID00	01 ~ 32	00
12	Baud Rate	B	B 96	96 / 192 / 384 / 576 / 1152	96
13	Temperature Unit		C	C / F	C

Output

Milliamp Output

The milliamp output is an analog output you can connect directly to:

1) Display Panel
2) Recording Device
3) Chart Recorder
4) PLC
5) Controller

Wahl provides 4 to 20mA (default) and 0 to 20mA, switchable in control panel.

Relay Output

Relay output relates to the currently displayed temperature on display. The relay output can be used to indicate an alarm state or to control external actions. The relay contacts can be set to:

- N.O. normally open: relay contacts are open while in the home position

The relay output has one user selectable setpoint:

- Trigger Point

Input

The external input can be used to provide the following functions:

- digital triggering
- digital switching of the laser

Signal Processing

When an IR thermometer is employed in an on-line system, its signal may be subjected to large fluctuations. Time function features are useful to retain the signal levels that are more likely to represent the true target temperature.

There are two ways signals are processed in the Wahl Fixed IR.
ON-SITE is for the user to set up through the instrument keypad and view the data thru instrument LCD. On-site features include:

- Averaging
- Peak
- Valley

REAL TIME DATA uses Wahl's Fixed IR via RS485 and protocol with the users' own Windows-based software.
Real time data features:

- Averaging

- Peak
- Valley

Plus:

- Peak-Picking
- Peak-Picking with reset
- Peak-Picking delayed
- Valley-Picking
- Valley-Picking with reset
- Track & Hold

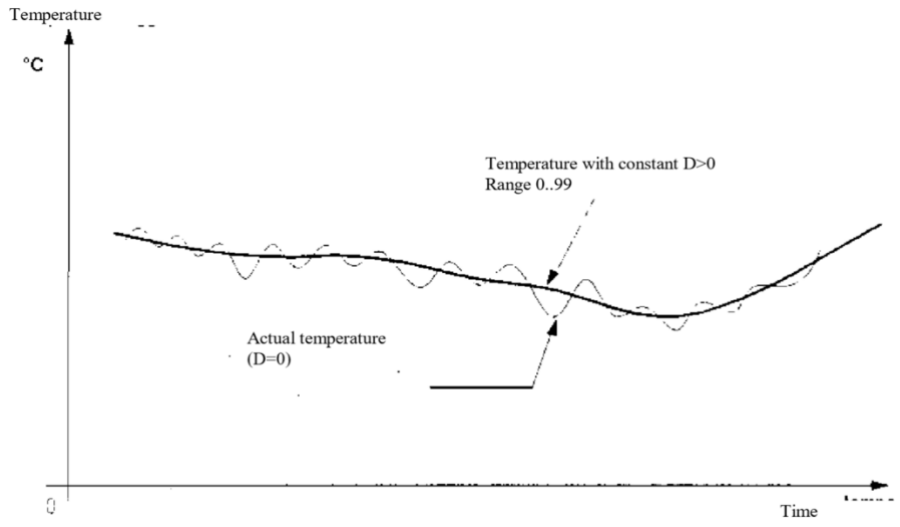
Average

Rapid temperature fluctuations about a true mean value can make the thermometer output unsuitable for recording and control. In this case, the average function can be used to provide a smoothed signal. The output signal Avu is given by:

Avu =Avp + (M – Avp) * 2 ΔT / D

where

M	Actual temperature
Avu	Output average
Avp	Previous average
ΔT	Sampling time = 20ms
D	Average time (sec) (programmable)



Peak

The Peak function holds a maximum temperature and retains it until a higher value appears or an external reset occurs.

Valley

The Valley function holds the minimum temperature and retains it until a lower value appears or an external reset signal occurs.

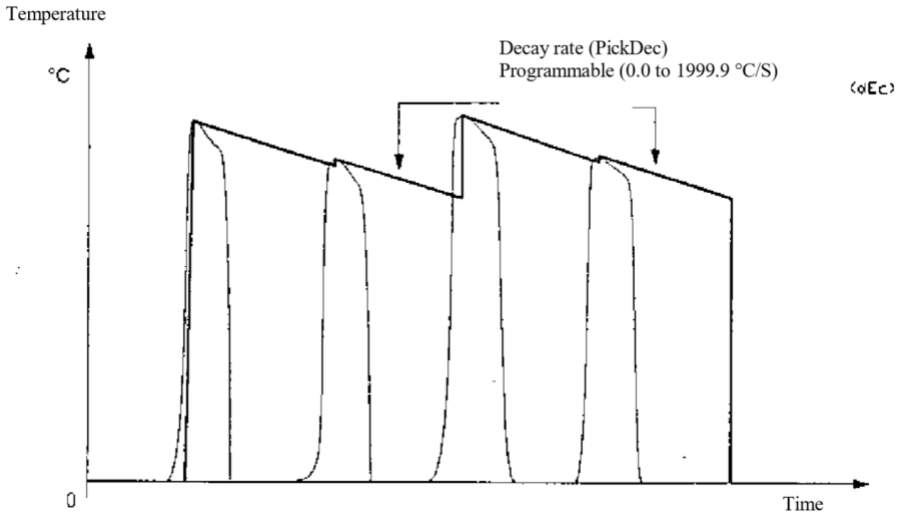
Peak-Picker

The peak-picker function holds a peak signal and allows it to decay slowly until the arrival of the next peak. It is used in such applications as rolling mills where the signal is occasionally lowered by steam, smoke, water droplets, metal scale, etc. When Peak-Picker function is programmed, the 4/20 mA output will follow the mathematical expression below:

$U = Peak – (PickDec * 2 \Delta T)$

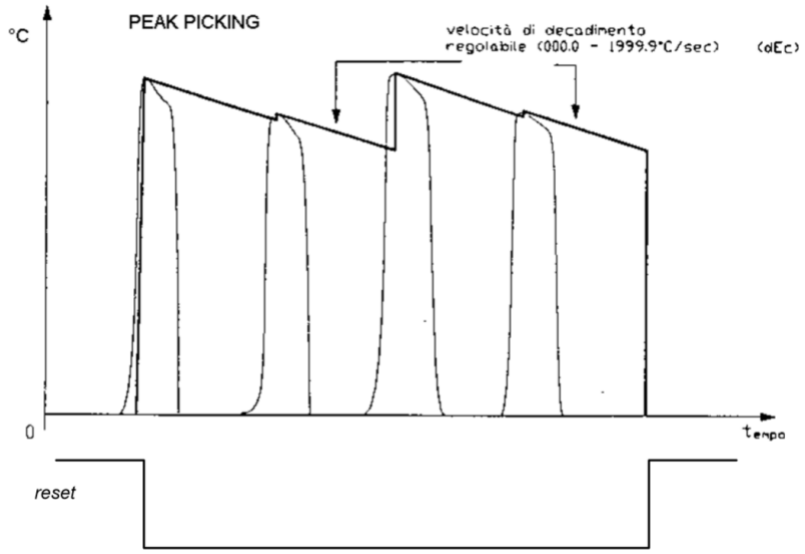
where

U	=	output signal
Peak	=	peak signal
PickDec	=	Decay rate °C/sec (programmable)
ΔT	=	sampling time



Peak-Picker with reset

When the Peak-Picker with reset function is selected, the external reset input is used to force the signal output to the current temperature measurement.

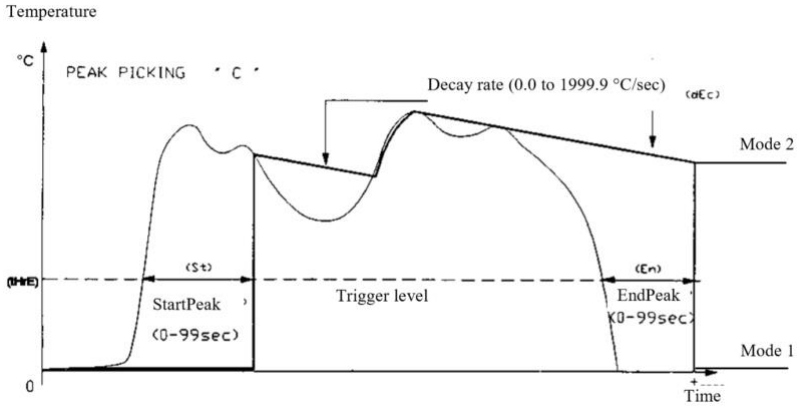


Peak-Picker delayed

When the Peak-Picker delayed function is selected, you have to set the following parameters:

PickDec	=	Decay rate
Threshold	=	Temperature threshold level
StartPeak	=	delay for starting peak-picking
EndPeak	=	delay for ending peak-picking
Delayed Mode 2	=	when selected, enable mode 2

- When the signal exceeds the programmed trigger level (Threshold), the thermometer will hold for the "StartPeak" delay before beginning the standard Peak-Picker function.
- When the input signal decreases below the trigger level (Threshold), the thermometer will hold for the "EndPeak" delay before resetting the output signal.
- The output signal will be reduced to low scale if Mode 1 is selected or the last calculated value if Mode 2 is selected.



Valley-Picker

Reverse the Peak-Picker function to define the Valley-Picker function.

U = Valley + (PickDec * 2 ΔT)

where

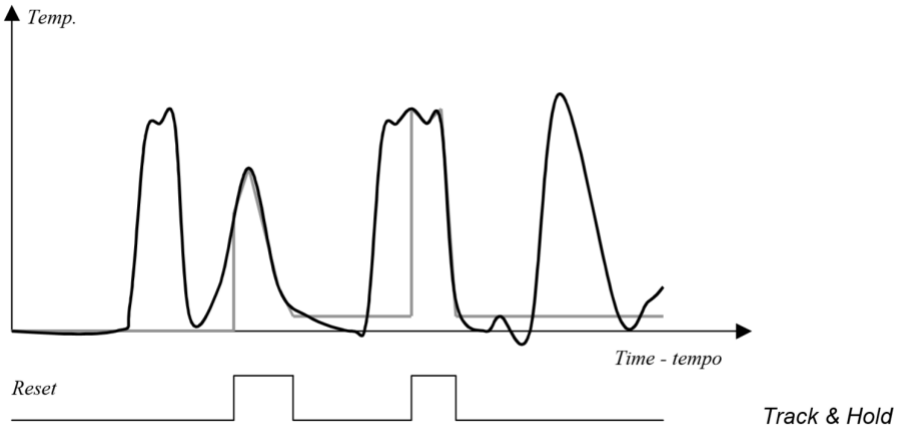
U	=	Output signal
Valley	=	Valley signal
PickDec	=	Decay rate °C/sec
ΔT	=	Sampling time

Valley-Picker with reset

Reverse the Peak-Picker with the reset function to define the Valley-Picker with reset.

Track and Hold

The Track (sample) and Hold function allows smoothed signals to be obtained from intermittent events. These may originate from objects on a conveyor belt or targets where the view is periodically obscured by rotating machinery. The output sampling is activated by a command signal received by an external switch that can be actuated by the belt or rotating machinery itself. The output is held when the switch is operated until the next command is received.



R Series Communication Protocol

A protocol is used to write custom programs for applications.

Temperature Measuring Unit (TMU) Protocol

Red Text indicates sending to the TMU

Blue Text indicates receiving from the TMU

1) Communication follows RS485 standard, baud rate can be set up thru TMU keypad, 9600, 19200, 38400, 57600, 115200, bit/s, 8 data bits, no check bit, 1 stop bit.
2) Setup Temperature Measuring Unit (TMU) address:
    a. Send hexadecimal numeral C0 XX 43 YY YY with their complement code (5 bytes total)
        i. C0 – SYNC Code
        ii. XX – Address of TMU, Range – 0 to 32
        iii. YY – New Address of TMU, Range – 0 to 32
        iv. Both fourth byte and fifth byte are the same
    b. No feedback from TMU
3) Transmission rate setting
    a. Send hexadecimal numeral C0 XX 53 YY YY with their complement code (5 bytes total)
        i. XX – Address of TMU, Range – 0 to 32
        ii. YY –transmission, Range 10 to 100 (0.10 to 1.00 with 0.01 increment)
        iii. If XX matches YY in 2, then change transmission, otherwise no action
        iv. Both fourth byte and fifth byte are the same
    b. No feedback from TMU
4) Emissivity Setting
    a. Send hexadecimal numeral C0 XX 54 YY YY with their complement code (5 bytes total)
        i. XX – Address of TMU, Range – 0 to 32
        ii. YY – Emissivity, Range 10 to 100 (0.10 to 1.00 with 0.01 increment)
        iii. If XX matches YY in 2, then change emissivity, otherwise no action
        iv. Both fourth byte and fifth byte are the same
    b. No feedback from TMU
5) Laser Setting
    a. Send hexadecimal numeral C0 XX 50 01 01 with their complement code (5 bytes total)
        i. XX – Address of TMU, Range – 0 to 32
        ii. Turn ON laser
    b. No feedback from TMU
    c. Send hexadecimal numeral C0 XX 50 00 00 with their complement code (5 bytes total)
        i. XX – Address of TMU, Range – 0 to 32
        ii. Turn OFF laser
    d. No feedback from TMU
6) Setting Alarm – Low Limit
    a. Send hexadecimal numeral C0 XX 51 YY ZZ with their complement code (5 bytes total)

i. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol no. 2 or thru the manual setting on TMU.
ii. Alarm Low Limit = (YY*256+ZZ) within measuring range
iii. If setting is lower than measuring range, it means Low Alarm is off.
iv. If setting is higher than measuring range, it is invalid data.

b. No feedback from TMU

7) Setting Alarm – High Limit
   a. Send hexadecimal numeral C0 XX 52 YY ZZ with their complement code (5 bytes total)
      i. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol no. 2 or thru the manual setting on TMU.
      ii. Alarm High Limit = (YY*256+ZZ) within measuring range
      iii. If setting is higher than measuring range, it means High Alarm is off
      iv. If setting is lower than measuring range, it is invalid data.
   b. No feedback from TMU
8) Sub Range Setting – 4mA
   a. Send hexadecimal numeral C0 XX 48 YY ZZ with their complement code (5 bytes total)
      i. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol no. 2 or thru the manual setting on TMU.
      ii. 4mA related temperature = (YY*256+ZZ)
      iii. The temperature gap between 4mA and 20mA should be ≥100°C.
   b. No feedback from TMU
9) Sub Range Setting – 20mA
   a. Send hexadecimal numeral C0 XX 49 YY ZZ with their complement code (5 bytes total)
      i. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol no. 2 or thru the manual setting on TMU.
      ii. 20mA related temperature = (YY*256+ZZ)
      iii. The temperature gap between 4mA and 20mA should be ≥100°C.
   b. No feedback from TMU
10) Read Temperature
   a. Send hexadecimal numeral C0 XX 55 55 55 with their complement code (5 bytes total)
      i. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol no. 2 or thru the manual setting on TMU.
   b. If XX matches YY in protocol no. 2. TMU send temperature back, otherwise no action.
   c. Temperature format: hexadecimal numeral F0 XX AB CD EF with their complement code of AB CD EF (5 bytes total)
      i. F0 – SYNC Code
      ii. XX - Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol No. 2 or thru the manual setting on TMU.
      iii. AB CD EF – Decimal temperature with +/- info

+ / -	Thousands	Hundreds	Tens	Units	decimal
A	B	C	D	E	F
BYTE 3		BYTE4		BYTE5	

11) Read Ambient Temperature
    a. Send hexadecimal numeral C0 XX 41 41 41 with their complement code (5 bytes total)
    b. XX – Address of TMU, Range – 0 to 32, XX here should match the setting thru protocol No. 2 or thru the manual setting on TMU.
    c. If XX matches YY in 2. TMU send temperature back, otherwise no action.
    d. Temperature format: hexadecimal numeral F0 XX AB CD EF with their complement code of AB CD EF (5 bytes total)
        i. F0 – SYNC Code
        ii. XX - Address of TMU, Range – 0 to 32
        iii. AB CD EF – Decimal temperature with +/- info

+ / -	Thousands	Hundreds	Tens	Units	decimal
A	B	C	D	E	F
BYTE 3		BYTE4		BYTE5	

Plus = 0, Minus = 8

For example,

1. -20.2 °C = 80 02 02
2. -19.1 °C = 80 01 91
3. 1.0°C = 00 00 10
4. 1200.0°C = 01 20 00
5. Resolution 1°C

12) Error Code

When TMU receives reading order, if the unit is out of working situation, TMU will feedback with 5 bytes:

a. F0 XX 80 27 40 - Reading is below Range Low Limit
b. F0 XX 03 10 00 - Reading is higher above Range High Limit
c. F0 XX 80 30 00 - Ambient temperature is lower than -20°C
d. F0 XX 00 65 00 - Ambient temperature is higher than 60°C

Note: XX – address of TMU.

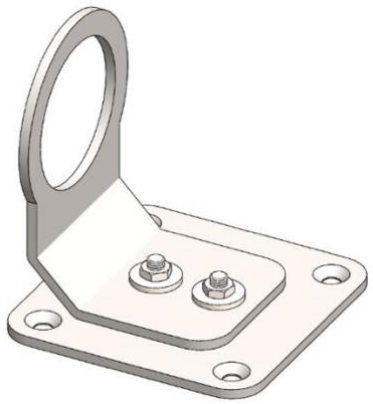
Accessories Guide

This chapter shows the full range of available accessories that can be supplied with the measuring systems. Special configurations or mounting systems can be provided to satisfy every application necessity. We are happy to help you choose the best option.

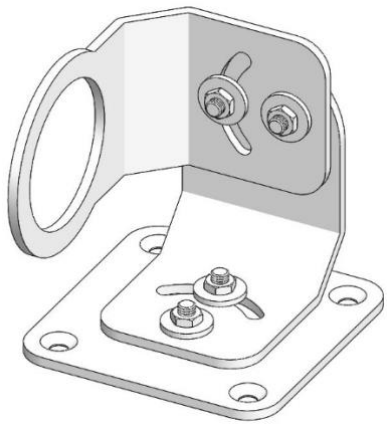
Surface Mount Bracket

When the thermometer is installed with standard environmental conditions you do not need to use any special cooling or lens cleaner systems. The thermometer can be installed directly on your process.

1) Fixed Surface Mount Brackets, 1 Axis

R40 Surface Mount Bracket (ø45mm, 1.77 in) 1 Axis P/N: 16451


2) Surface Mount Bracket, 2 Axis

R40 Surface Mount Bracket (ø45mm, 1.77 in) 2 Axis P/N: 16453


Wall Mount Flange

R40 Wall Mount Flange
• M30x1 male from Fixed IR / Air Purge side P/N 16483-44

Wall Mount Flange M30x1 Male

Air Purge

An Air Purge is used to eliminate dust, dirt, heat, steam, smoke, fumes, particles or vapors from the front of the optical head, and to keep the lens clean. This air purge can also be used to cool the thermometer when necessary.

R40 Air Purge, M44x1.5 to M30x1
P/N: 16472


Protective Window for R40 units

Protective windows are necessary in excessively harsh environments.

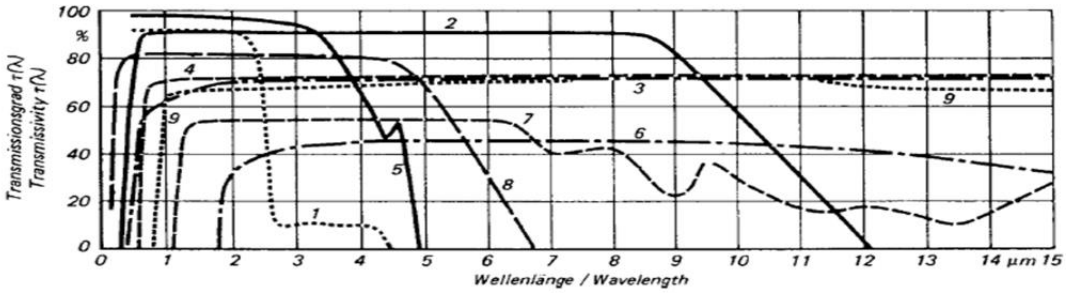
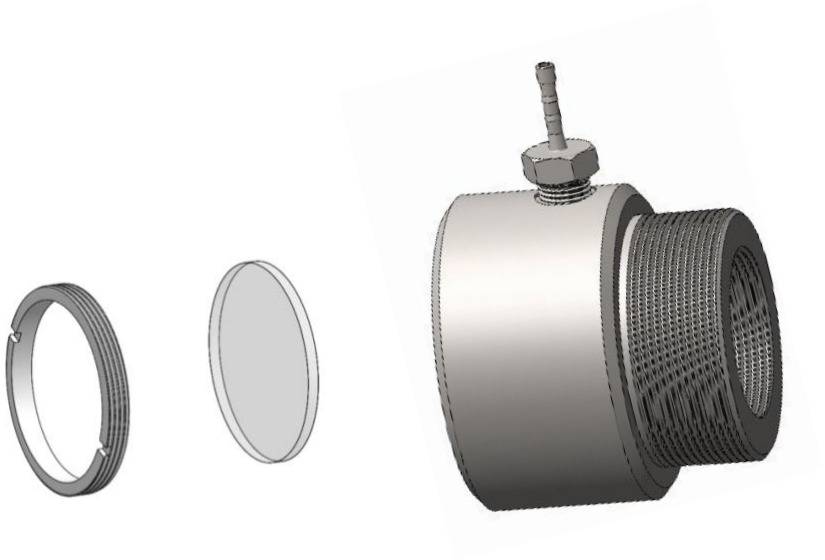


Fig. 13: Transmittance of typical IR materials (1 mm thick)

1- Optical glass
2- Calcium fluoride (CaF)
3- Zinc selenide (ZnSe)
4- KRS-5
5- Quartz glass
6- Germanium
7- Silicon
8- Lithium fluoride
9- Chalcogenide glass IG-2

	Part Number	Material	Models used for:
Window	16465-1	BK7	1M, 2M
	16465-2	Sapphire	1M, 2M, MT, F4, G5
	16465-3	ZnSe	P3, MT, F4, G5, P7, LT



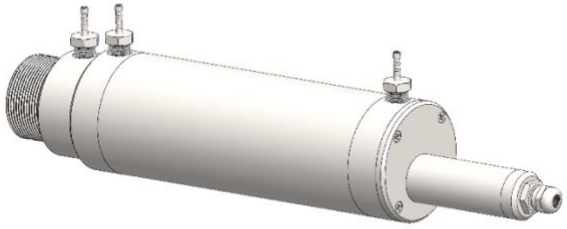
Note: Locking ring is included with protection windows.

Note: window not needed on 3M units.

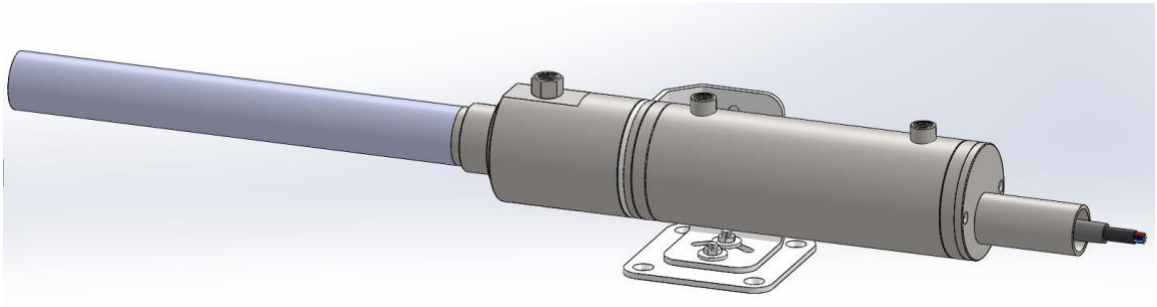
R40 Cooling Jacket

	Model	Ambient Range
R40 Cooling Jacket	16460	Up to 350°F (175°C)

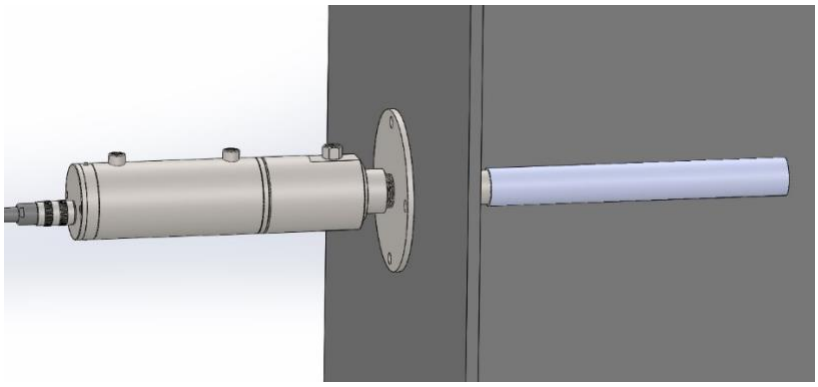
1) Cooling Jacket (350°F /175°C) P/N: 16460



2) R40 with 2-Axis Mounting Bracket, Air Purge and Water Cooling Jacket

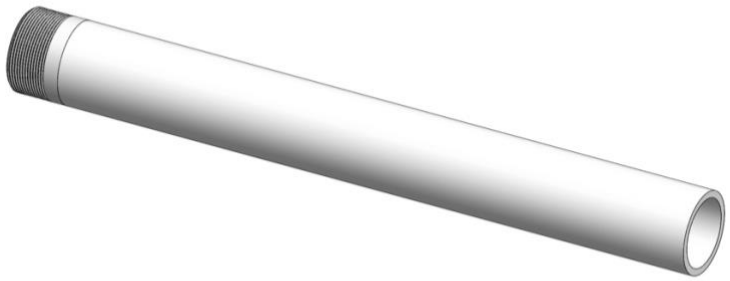


3) R40 with Flange, Air Purge, and Water Cooling Jacket and Sighting Tube



Sighting Tube

Use a sighting tube to avoid reflected energy in temperature measurement environments. The sighting tubes must be used when the target is covered by fumes or flames. They should be used together with an air purge system to help you have a clean viewing path from target to the thermometer.



Sighting Tube 11.81 in (300 mm) Long	304SS	Inconel	High Purity Alumina
	1500°F 800°C	2000°F 1100°C	3500°F 1900°C
R40	P/N: 16491-1	P/N: 16491-2	P/N: 16491-4

Cable

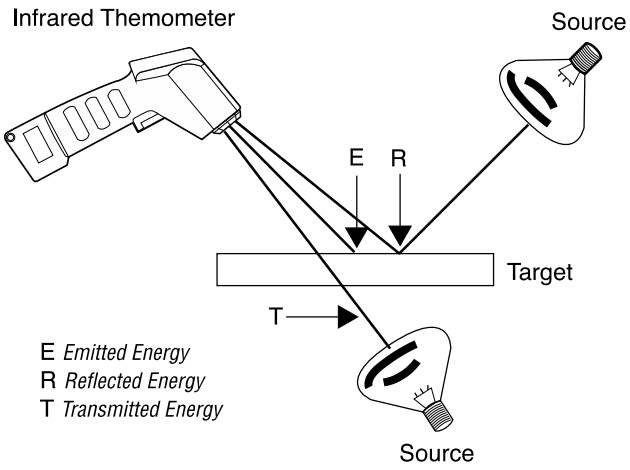
	Standard Cable	High Temperature Cable
Model	16118	16119
Temperature Range	-20 to 105°C	-80 to 200°C
Voltage Rating	300 VRMS	300 VRMS
Capacitance	23.5 pf/ft @1 kHz, Nominal Conductor to Conductor	13.1 pF/ft @1 kHz, Nominal Conductor to Conductor
Inductance	0.18 µH/ft, Nominal	0.19 µH/ft, Nominal
Conductor	DCR 16.4 Ω/1000ft @20°C, Nominal	DCR 26 Ω/1000ft @20°C, Nominal

Industrial Power Supply

16116	16117
	
• Compact AC-DC power supply • Universal input 24VAC • 31W • Class II power supply with 3kVAC isolation • Low cost AC/DC power supply • Short circuit & over current protected • IEC/EN/UL60950 certified • For use outside control box	• Economical • 24VAC • 25W to 150W • Small size • For use inside control box

Emissivity

Emissivity in infrared (IR) measurement refers to the ability of the surface being measured to emit radiation. Surfaces vary in emissivity and this must be taken into account before accurate readings can be obtained. The emissivity ratio represents the amount of radiated energy that the measured surface returns to the instrument. A return of 100% of the energy is measured as 1.0 emissivity. If all the radiated energy is reflected and/or transmitted and none emitted, the emissivity ratio is 0.0. A perfect radiator such as a black body, has a 1.0 emissivity ratio and a very shiny or highly-polished surface has a ratio of 0.2 or lower. Most textured or painted surfaces have an emissivity ratio of around 0.95. DHS40 Series Wahl Heat Spy thermometers feature adjustable emissivity from 0.10 to 1.00.



One of three things will happen to the energy as it reaches the sensor:

E - Emitted Energy - Some energy will be absorbed and converted into heat.

R - Reflected Energy - Some energy will be reflected from the surface of the material.

T - Transmitted Energy - Some energy will be transmitted completely through the material.

As one or more of these three things must happen to the energy, the amount of energy absorbed, reflected and transmitted must add up to 100%. Therefore, the coefficients of absorption, reflection and transmission (E, R, and T) must equal 1.

The ideal material in non-contact temperature measurement and, in fact, the source against which instruments are calibrated is the black body. This is defined as a surface which emits the maximum amount of radiation at a given temperature. The name "black body" is misleading because it implies color - the color of the material is not as important as the surface finish. Materials which are good radiators (absorbers) and approximate black body conditions are carbon, asbestos, and rubber. Highly polished metals are poor black bodies and therefore good reflectors.

As long as the emissivity setting on the instrument is properly set with respect to the material being measured, all measurements with the infrared thermometer will be precise.

The emissivity can be determined by one of the following methods, in order of preference:

1. Determine the actual temperature of the material using a sensor such as a RTD, thermocouple or another suitable method. Next, measure the object temperature and adjust the emissivity setting until the correct value is reached. This is the correct emissivity for the measured material.

2. For relatively low temperature objects (up to 260°C or 500°F), place a piece of tape, such as a masking tape, on the object. Make sure the tape is large enough to cover the field of view. Next, measure the tape temperature using an emissivity setting of 0.95. Finally, measure an adjacent area on the object and adjust the emissivity setting until the same temperature is reached. This is the correct emissivity for the measured material.

3. If a portion of the surface of the object can be coated, use a flat black paint, which will have an emissivity of about 0.98. Next, measure the painted area using an emissivity setting of 0.98. Finally, measure an adjacent area on the object and adjust the emissivity setting until the same temperature is reached. This is the correct emissivity for the measured material.

Typical Emissivity Values

The table in Appendix I provides a brief reference guide to determine emissivity and can be used when one of the above methods is not practical. Emissivity values shown in the table are only approximate, since several parameters may affect the emissivity of an object. These include the following ones:

1. Temperature
2. Angle of Measurement
3. Geometry (plane, concave, convex, etc.)
4. Thickness
5. Surface Quality (polished, rough, oxidized, sandblasted)
6. Spectral region of measurement
7. Transmissivity (e.g., thin film plastics)

To optimize surface temperature measurements, consider the following guidelines

1. Determine the object emissivity using the instrument to be used for the measurement.
2. Avoid reflections by shielding the object from surrounding high temperature sources.
3. For higher temperature objects, use the shortest wavelength instrument for your temperature range.
4. For semi-transparent materials such as plastic films and glasses, ensure that the background is uniform and lower in temperature than the object.
5. Mount or hold the sensor perpendicular to the surface whenever the emissivity is less than 0.90. In any case, do not exceed angles more than 30 degrees from incidence.

Maintenance and Troubleshooting

Each R series Fixed IR is factory calibrated and certified against Wahl Standards. A NIST Certificate of Conformance stating the nominal and actual values and the deviation error is available separately. The instrument calibration must be periodically verified.

The R series uses sophisticated analog and digital technology. All maintenance operations must be carried out by qualified personnel.

For the instrument to function correctly the optic system must be kept clean and must not reach temperatures higher than those specified. The maintenance department should ensure these working conditions with a periodical check of the cooling system and cleaning the lens.

Purge Air Supply

Air filter cleanliness must be checked at regular intervals.

Our suggestion is to check it every day, and then determine a correct time interval based on your experience.

If the optic system reaches temperatures higher than the working temperatures specified, it has to be recalibrated at the factory.

The air purge device is to be accurately checked, as the diffuser may become obstructed by contaminated air. When this happens, the air flow from the diffuser is not uniform, and dust particles appear on the lens. In this case, the diffuser should be washed in a detergent solution and blown with compressed air, then dried. Proper air filtering will solve this problem.

Water Supply

Verify the water flow according to your experience: daily first, and then when the system is running well, weekly. Check the thermometer temperature: it has to be high enough to prevent any condensation formation. Once the water continuity is defined, it's enough to verify the support temperature.

WARNING! If the temperature of the thermometer becomes too high due to the absence of water or to a partial flow interruption, it must be verified and re-calibrated by the manufacturer. Please call Customer Service for an RMA to send your unit back for recalibration.

Optic Cleaning

Remove the connection wires from the terminal board.

Remove the thermometer from its support. Verify the cleanliness of the internal part of the cylinder by removing any dirt particles or oil.

If necessary, clean the lens with a very soft cloth and then reinstall the thermometer. Verify the alignment and reconnect everything. Use an air purge system to keep the lens clean.

Mounting Device

Verify at regular intervals that these devices are in good condition and that no damage has occurred.

Interconnection Cable

Verify at regular intervals that cables are in good condition and that no damage has occurred. Verify that the connections between the indicator and the acquisition system are secure.

Error Codes

	Description	Action
LOCK	mP in protection mode	Return for Unlock
ERR	Calibration data loss	Return for Calibration
Blank with Light ON	Firmware data loss	Return for Firmware reload and Calibration
Blank with Light OFF	Electronic failure	Return to factory

Return for Calibration Service

To receive a NIST Traceable Certificate of Conformance or repair service on your product, go to palmerwahl.com and click on: Request an RMA (Return Material Authorization Number) and follow the instructions. You will receive your RMA number via email once your item is received at our facility. If you prefer, call Customer Service at: 1-800-421-2853 for assistance with the RMA process. Material being returned to us should be packed well, preferably in the original shipping container.
Our quality management system is certified to conform to ISO 9001:2015. We maintain a calibration system in conformance with ANSI/NCSL Z-540 and MIL-STD-45662A.

All calibrations are performed against standard instruments, traceable to NIST. Records are stored for a minimum of three years. Standards used have a test ratio of four times greater than the unit being calibrated. We can perform certified, traceable calibrations in support of companies that require meeting FAA and FDA quality standards.

Palmer Wahl Instruments, Inc.
234 Old Weaverville Road
Asheville, NC 28804
Phone: 800-421-2853 • 828-658-3131
FAX: 828-658-0728
Email: info@palmerwahl.com
www.palmerwahl.com

Appendix I: Emissivity of Common Materials

Hints for Choosing and Using

Know your target

What is the emissivity? How clear is the optical (IR) path to the target? Are reflections a concern? What is the expected temperature range you will need to measure?

Know your spot size

The target must completely fill the sensitive area in order to get accurate readings.

Have realistic expectations

If you need to know the temperature within 1 degree Fahrenheit, you should use another technology, like a RTD contact probe.

Stabilization

Allow the IR thermometer to stabilize at the temperature where it will be used for at least 30 minutes for an accurate reading.

Keep the lens clean

Also watch out for dusty or vapor-filled optical paths.

Accuracy concerns

If accuracy is a concern, buy a model with adjustable emissivity. If you're just looking for "hot spots" a fixed emissivity model will work well.

Always remember

You are only measuring surface temperature. If you need the temperature of a mixture, use an immersion probe and an electronic thermometer.

How It Works

All solid objects emit infrared energy above absolute zero. The amount of energy emitted is proportional to the body temperature. Wahl's Heat Spy® directs this energy by means of fixed focus optics into a sensitive detector, which is amplified and processed by the computer to temperature readings in °F or °C. It is fast, because IR energy travels at the speed of light, and the detector has a very low mass. The time constant is 0.1 second, about 10 times faster than conventional contact methods. Measurements are displayed in less than one second.

When to Use

Temperature at a Distance

You can stand 1 to 40 feet away and conveniently measure temperature of bearings, kilns, and furnace walls. You can locate hot spots in reactor shells, steam piping, and insulation surfaces. Specialty models can be used to up to 300 feet away from your temperature target.

Temperature of Moving Material

Moving materials require two Heat Spy features not available by any other method: non-contact with the process material, and fast-measurement of rapidly moving materials. Measure continuously moving solid materials like plastic film and extrusions, pulp and paper, textiles, rubber, steel sheets, coating, or painting.

Temperature of Small, Low Mass Material

Electronic components or other small or low mass items can be measured with a Wahl Heat Spy, where a contact thermometer would change the measured condition through heat transfer.

Temperature of areas too hot for personnel

In foundries, forging shops, glass factories and power plants, the Wahl Heat Spy allows you to stand away from the heat or high voltage.

Temperature of Rough Surfaces

The Wahl Heat Spy does not require contact with the target. It measures rough and uneven surfaces and averages temperature readings of the observed target area. It affords users an efficient method of measuring the temperature of granular materials, rough castings, and forgings.

Temperature requiring quick measurement

Opening and closing of injection molding dies requires temperature to be measured in less than 2 seconds. The Wahl Heat Spy is ideal for use with rotating machinery, like large motor armatures and drive couplings.

Emissivity Table

Metals

Infrared Models	1M	2M	3M	P3, MT, F4, G5	P7, G7, LT
Spectral Range	1.0 µm	1.6 µm	2.3 µm	5.1 µm	8-14 µm
Aluminum					
Non-Oxidized	0.1-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.02-0.1
Oxidized	0.4	0.4	0.2-0.4	0.2-0.4	0.2-0.4
Alloy A 3003					
Oxidized	--	0.4	0.4	0.4	0.3
Roughened	0.2-0.8	0.2-0.6	0.2-0.6	0.1-0.4	0.1-0.3
Polished	0.1-0.2	0.02-0.1	0.02-0.1	0.02-0.1	0.02-0.1
Brass					
Polished	0.8-0.95	0.01-0.05	0.01-0.05	0.01-0.05	0.01-0.05
Burnished	--	--	0.4	0.3	0.3
Oxidized	0.6	0.6	0.6	0.5	0.5
Carbon					
Non-oxidized	0.8-0.95	0.8-0.9	0.8-0.9	0.8-0.9	0.8-0.9
Graphite	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.8
Chromium	0.4	0.4	0.05-0.3	0.03-0.3	0.02-0.2
Copper					
Polished	0.05	0.03	0.03	0.03	0-03
Roughened	0.05-0.2	0.05-0.2	0.05-0.2	0.05-0.15	0.05-0.1
Oxidized	0.2-0.8	0.2-0.9	0.7-0.9	0.5-0.8	0.4-0.8
Gold	0.3	0.01-0.1	0.01-0.1	0.01-0.1	0.01-0.1
Haynes Alloy	0.5-0.9	0.6-0.9	0.6-0.9	0.3-0.8	0.3-0.8
Inconel					
Oxidized	0.4-0.9	0.6-0.9	0.6-0.9	0.6-0.9	0.7-0.95
Sandblasted	0.3-0.4	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6
Electropolished	0.2-0.5	0.25	0.25	0.15	0.15
Iron					
Oxidized	0.4-0.8	0.5-0.9	0.5-0.9	0.6-0.9	0.5-0.9
Non-oxidized	0.35	0.1-0.3	0.1-0.3	0.05-0.25	0.05-0.2
Rusted	--	0.6-0.9	0.6-0.9	0.5-0.8	0.5-0.7
Molten	0.35	0.4-0.6	0.4-0.6	--	--
Iron, Cast					
Oxidized	0.7-0.9	0.7-0.9	0.7-0.9	0.65-0.95	0.6-0.95
Non-oxidized	0.35	0.3	0.1-0.3	0.25	0.2
Molten	0.35	0.3-0.4	0.3-0.4	0.2-0.3	0.2-0.3
Iron Wrought					
Dull	0.9	0.9	0.95	0.9	0.9
Lead					
Polished	0.35	0.05-0.2	0.05-0.2	0.05-0.2	0.05-0.1
Rough	0 65	0.6	0.6	0.4	0-4
Oxidized	--	0.3-0.7	0.3-0.7	0.2-0.6	0.2-0.6
Magnesium	0.3-0.8	0.05-0.3	0.05-0.3	0.03-0.15	0.02-0.1
Mercury	--	0.05-0.15	0.05-0.15	0.05-0.15	0.05-0.15
Molybdenum					
Oxidized	0.5-0.9	0.4-0.9	0.4-0.9	0.3-0.7	0.2-0.6
Non-oxidized	0.25-0.35	0.1-0.3	0.1-0.3	0.1-0.15	0.1
Monel (Ni-Cu)	0.3	0.2-0.6	0.2-0.6	0.1-0.5	0.1-0.14
Nickel					
Oxidized	0.8-0.9	0.4-0.7	0.4-0.7	0.3-0.6	0.2-0.5
Electrolytic	0.2-0.4	0.1-0.3	0.1-0.3	0.1-0.15	0.05-0.15
Platinum					
Black	--	0.95	0.95	0.9	0.9

Infrared Models	1M	2M	3M	P3, MT, F4, G5	P7, G7, LT
Spectral Range	1.0 µm	1.6 µm	2.3 µm	5.1 µm	8-14 µm
Silver	0.04	0.02	0.02	0.02	0.02
Steel					
Cold-Rolled	0.8-0.9	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9
Ground Sheet	--	--	--	0.5-0.7	0.4-0.6
Polished Sheet	0.35	0.25	0.25	0.15	0.1
Molten	0.35	0.25-0.4	0.25-0.4	0.1-0.2	--
Oxidized	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.9
Stainless	0.35	0.2-0.9	0.2-0.9	0.15-0.8	0.1-0.8
Tin (Non-oxidized)	0.25	0.1-0.3	0.1-0.3	0.05	0.05
Titanium					
Polished	0.5-0.75	0.3-0.5	0.3-0.5	0.1-0.3	0.05-0.2
Oxidized	--	0.6-0.8	0.6-0.8	0.5-0.7	0.5-0.6
Tungsten		0.1-0.6	0.1-0.6	0.05-0.5	0.03
Polished	0.35-0.4	0.1-0.3	0.1-0.3	0.05-0.25	0.03-0.1
Zinc					
Oxidized	0.60	0.15	0.15	0.1	0.1
Polished	0.5	0.05	0.05	0.03	0.02

Non-Metals

Infrared Models	1M	2M	3M	P3, MT, F4, G5	P7, G7, LT
Spectral Range	1.0 µm	1.6 µm	2.3 µm	5.1 µm	8-14 µm
Asbestos					
Asbestos	0.9	0.8	0.8	0.9	0.95
Asphalt	--	--	--	0.95	0.95
Basalt	--	--	--	0.7	0.7
Carborundum	--	0.95	0.95	0.9	0.9
Ceramic	0.4	0.8-0.95	0.8-0.95	0.85-0.95	0.95
Clay	--	0.8-0.95	0.8-0.95	0.85-0.95	0.95
Concrete	0.65	0.9	0.9	0.9	0.95
Cloth	--	--	--	0 95	0.95
Glass					
Plate	--	0.2	0.2	0.98	0.85
"Gob"	--	0.4-0.9	0.4-0.9	0.9	
Gravel	--	--	--	0.95	0.95
Gypsum	--	--	--	0.4-0.97	0.8-0.95
Ice	--	--	--	--	0.98
Limestone	--	--	--	0.4-0.98	0.98
Paint	--	--	--	--	0.9-0.95
Paper (any color)	--	--	--	0.95	0.95
Plastic (opaque, >20	--	--	--	0.95	0.95
Rubber	--	--	--	0.9	0.95
Sand	--	--	--	0.9	0.9
Snow	--	--	--	--	0.9
Soil	--	--	--	--	0.9-0.98
Water	--	--	--	--	0.93
Wood (natural)	--	--	--	0.9-0.95	0.9-0.95