DHS40 SERIES
HIGH PERFORMANCE HAND HELD INFRARED PYROMETER
USER MANUAL

MODELS

DHS401M	**DHS40MT**	**DHS40P3**	**DHS40LT**
DHS402M	**DHS40F4**	**DHS40P7**	
DHS403M	**DHS40G5**		
	DHS40G7		

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Contents

Thank you for purchasing a Wahl High Performance Hand-Held Infrared Pyrometer.
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.

Includes

The DHS40 comes included with 9V Alkaline Battery (PN:12232), Trigger Lock (PN:9852), Carrying Case (PN: 12423-04), Certificate of Conformance (on packing slip), and user manual (available for download).

DHS40 Specifications

High Performance Hand-Held Infrared					
MEASURING SPECIFICATIONS	Model Numbers	1M / 2M	3M	MT / F4 / G5 / G7 / P7 / LT	P3[4]
	Optical	100:1		30:1	
	Accuracy [1]	± 0.25% of reading or ± 1°C	± 3°C + 0.1% of reading	± 0.6% of reading or ± 1°C	
	Repeatability [2]	± 0.10% of reading		± 0.30% of reading	
	LCD Resolution	1°F / 1°C		1°F / 1°C	
	Response Time [3]	5 mS		150 mS	750 mS
	Emissivity	0.10 to 1.00		0.10 to 1.00	
ELECTRONIC SPECIFICATIONS	Meter Display	LCD with Backlight, 128 X 64 DOT			
	Keyboard	4 - Key - MENU, UP, DOWN, ENTER			
	Alarm	High or Low			
	Signal Processing	MAX / MIN / AVG / Delta T / Temperature			
SENSOR SPECIFICATIONS	Ambient Temperature	0° to 50°C (32° to 122°F)			
	Storage Temperature	-20° to 70°C (-4° to 158°F)			
	Relative Humidity	10% to 95% non-condensing			
POWER	Power Supply	9 V DC Battery			
	Battery Life	30 hours, approximately			
ENCLOSURE	Housing Material	Aluminum			
	Housing Dimensions	13 x 6 x 15.5 in (330.2 x 152.4 x 393.7mm)			
	Weight	2.2 lbs. (0.99 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 minuet warmup.

The Wahl DHS40 conforms to RoHS requirements according to EU Directive (EU) 2015/863- amending Annex II to Directive 2011/65/EU for restriction of Hazardous substances.

DHS40 Product Line

DHS40 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	150° to 1200°C (302° to 2192°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

DHS40 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)	Thick 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	-40° to 800°C (-40° to 1472°F)	Organic Materials Baking Production Painted Metal Surfaces Rubber, Tires Paper Textiles Thicker Plastics




Principle of Operation

DHS40 Series Hand-held-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, 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 pyrometer, 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

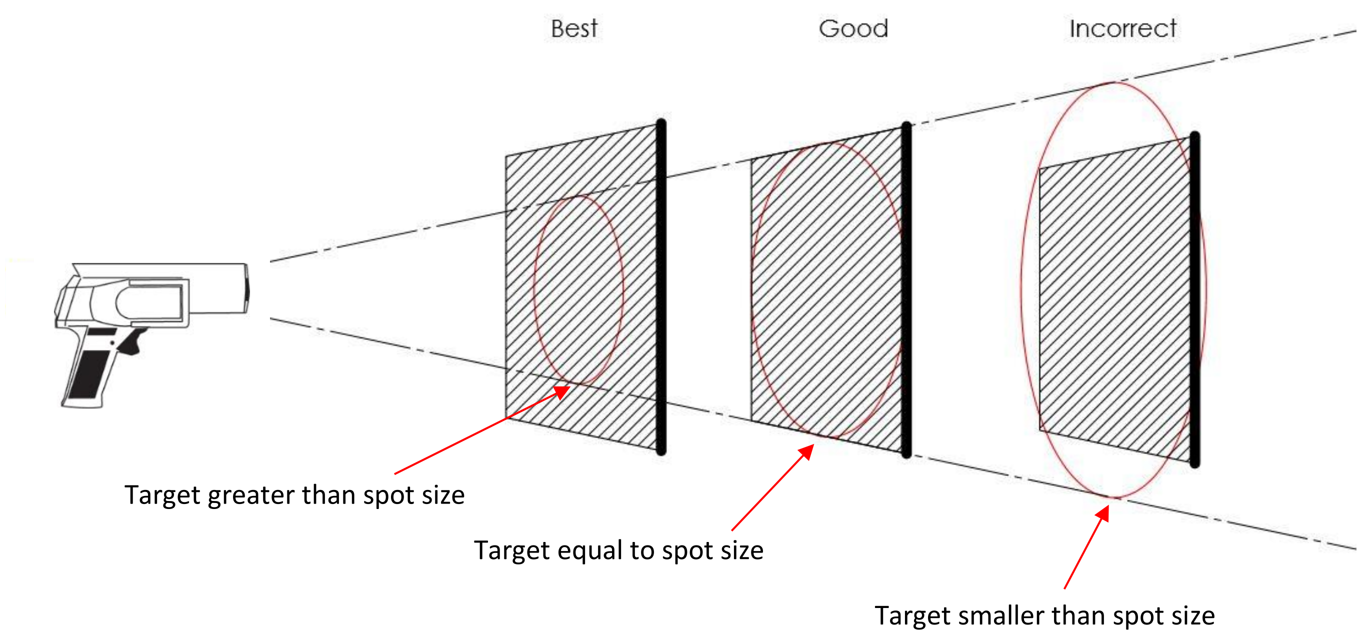
The actual area being measured is determined by the distance-to-spot ratio of the model you are using; this varies from model to model. As the distance from the object being measured increases, the spot size of the area being measured also increases.

Wahl provides two (2) optics options for the DHS40 model, one (1) for both the photodiode and one (1) for the thermopile versions.

Maximum Distance and Spot Size

Use the size of the object being measured, together with the optical resolution of the infrared pyrometer 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.

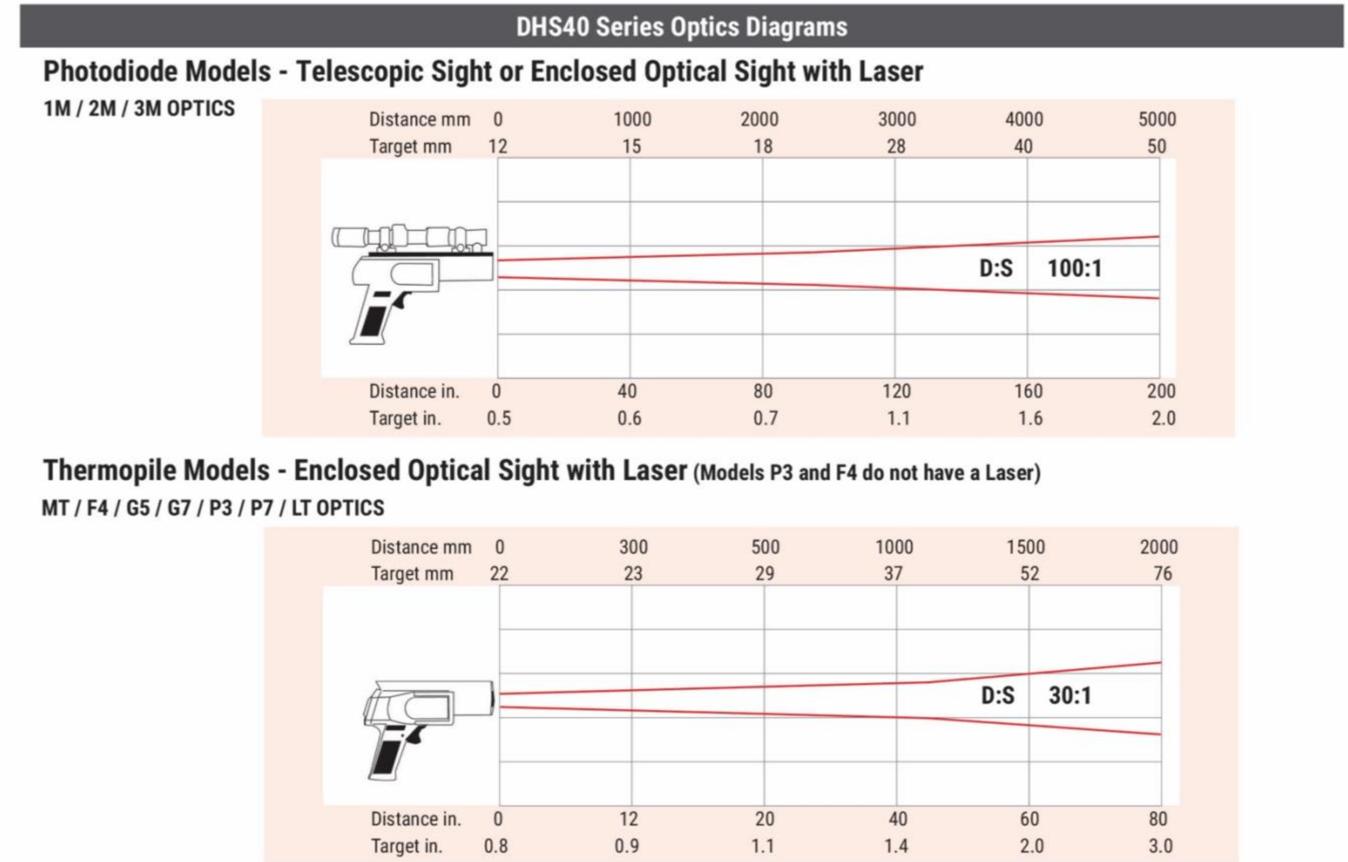
Proper Placement of Sensor:



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

Before using, 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.

DHS40 Optics Diagrams

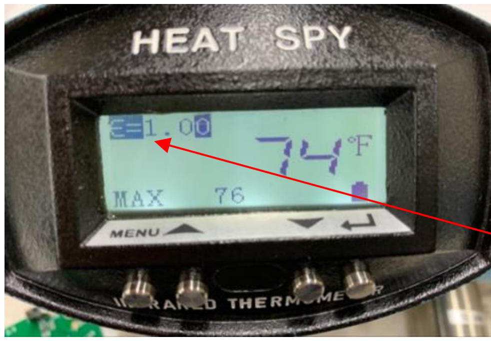


DHS40 Features

Trigger

The trigger is contoured to fit the index finger. This is a single position trigger, which turns the instrument on when pulled. The display will show blank for a fraction of a second before the first reading appears to allow the microprocessor to complete its initial calculation cycles.

LCD Display ICONS



Emissivity Setting

Transmission Setting

Backlight On/Off

Alarm Low

Alarm High

°F or °C

Hold Symbol

Battery Status

LCD Display ICONS		
Name	Symbol	Note
Emissivity	ε = x.xx	See pg. Emissivity section and Appendix I
Transmission	T = x.xx	Setting for 1M and 2M model, thru windows Glass: 0.92 Quartz: 0.88
Back Light	BLIGHT	ON or OFF
Alarm Low	ALM LO XXXX	OFF If ON: 4-digits will be display for setting value
Alarm High	ALM HI XXXX	OFF If ON: 4-digits will be display for setting value
C / F	C or F	Switch between °C / °F by use of the switch on the side of the unit
Hold	H	After trigger is released, all info on LCD will remain for 8 seconds
Battery Status	BAT Symbol	

Control Panel

4-Button: MENU / UP / DOWN / ENTER

When Trigger is Pressed

Far Left Button	Center Left Button	Center Right Button	Far Right Button
MENU	↑	↓	⏎

During Measuring (Default)

Far Left Button	Center Left Button	Center Right Button	Far Right Button
Entering measuring mode	Scrolling MAX/MIN/AVG/DEL in second temperature display		⏎

During Setting

Press "Menu" Button to enter Setting Mode

Far Left Button	Center Left Button	Center Right Button	Far Right Button
Emissivity	Increase Value	Decrease Value	Set Emissivity up to 2 digits
Transmission	Increase Value	Decrease Value	Set Transmission up to 2 digits
Back Light	Increase Brightness	Decrease Brightness	
High Alarm	Increase Value	Decrease Value	Set High Alarm up to 4 digits
Low Alarm	Increase Value	Decrease Value	Set Low Alarm up to 4 digits

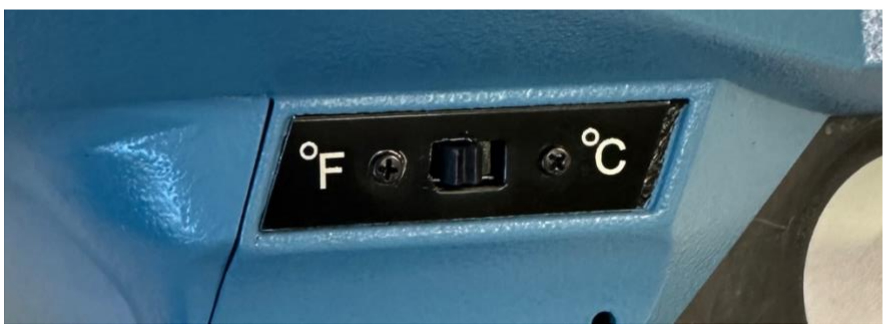
Press "Menu" Button to Save the Setting and proceed to the next setting

When Trigger is Released

Display will be held for 8 seconds

°F / °C Switch

The user can switch between °F and °C at any time. The real time reading will be changed instantly.



Laser Switch

All DHS40 models (except P3 and F4 models) include laser sighting.

Laser

The laser beam defines the center of the target to be measured by projecting a spot of high intensity red light on the target surface. *Note that the entire surface area to be measured is larger in diameter than the spot illuminated by the laser.* If desired, look through the enclosed optical sight to determine the entire diameter of the target.

The laser beam will not affect temperature readings. The beam will appear brightest in indoor light and dim in outdoor light. The enclosed optical sight is more effective in outdoor lighting conditions.

To activate laser sighting, turn on the laser power switch located on the left side of the DHS40 in the area just above the handle. Squeeze the trigger to activate the laser beam; release the trigger to deactivate.

To save battery life, turn off the laser power switch after use.

Laser Specifications

Power output: 1mW maximum
Wave length: 660 nm
Useful range: 100 feet (indoors)

Caution 

DO NOT AIM THE LASER AT THE EYE AS EYE DAMAGE WILL RESULT.

AVOID REFLECTIONS FROM SHINY OBJECTS SUCH AS MIRRORS, BRIGHT METAL AND GLASS.

THE REFLECTED LASER LIGHT IS JUST AS DANGEROUS AS THE DIRECT BEAM.

Optical Sight

The enclosed optical sighting system used in the DHS40 allows precise aiming at the required target field of view with compensation for parallax. What you see in the sight is the center of the spot you are measuring. Two circles are utilized on the optical sighting system, one marked 4 and the other marked 20. These correspond to exact target alignment at 4 and 20 feet and correct for parallax offset.

Telescopic Sight

The telescopic sighting system used in the DHS40 allows precise aiming at a longer distance, or when measuring targets at higher temperatures. A filter in the lens reduces the glare from high heat, allowing for accurate temperature measurement of the required target.

Tri-Pod Connection

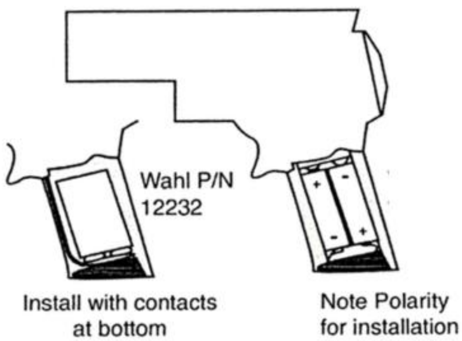
Standard threaded tri-pod mount is located in the base of the handle for tri-pod mounting which can be used to hold the DHS40 in one position for real time temperature reading.

Trigger Lock

At times, particularly for recording or calibrating, it is useful to mechanically lock the trigger in the pressed position. The DHS40 is designed to permit insertion of a pin in the housing and trigger to lock it in the "ON" position. A locking pin is supplied, but any 0.040 inch wire or pin can be used for this purpose. (Locking Pin PN: 9852)

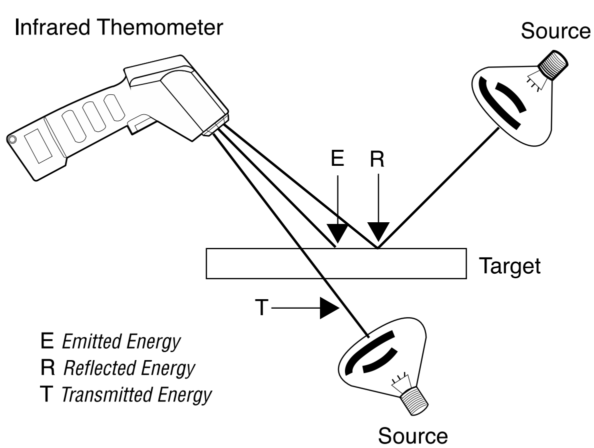
Power Source

The DHS40 is powered by a standard 9V type alkaline battery (Wahl PN: 12232). This battery is located in the handle, and is easily replaced. Normally, the battery supplied has 500 milliamp hours, providing about 140 hours of continuous duty. The battery is connected to the system with snap on clips which are polarized. When the battery cover is removed, a spring will push the battery out for easy access.



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 pyrometer 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 pyrometer 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 DHS40 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 DHS40 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. The maintenance department should periodically check the unit and clean the lens.

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.

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Appendix I: Emissivity of Common Materials

Hints for Choosing and Using

Know Your Target
What is the material? 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 pyrometer 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, use 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 DHS40 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 DHS40 features not available by any other temperature measuring methods: 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 DHS40, 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 DHS40 allows you to stand away from the heat or high voltage to measure the temperature up to 5500°F (3000°C),.

Temperature of Rough Surfaces

The DHS40 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 DHS40 is ideal for use with rotating machinery, like large motor armatures and drive couplings.

Emissivity Table

Metals

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

Spectral Range	1.0 µm	1.6 µm	2.3 µm	5.1 µm	8-14 µm
Platinum					
Black	--	0.95	0.95	0.9	0.9
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

Spectral Range	1.0 µm	1.6 µm	2.3 µm	5.1 µm	8-14 µm
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 mils)	--	--	--	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