

## IR Thermometers & Emissivity

### How do infrared (IR) thermometers work?

All objects emit infrared energy. The hotter an object is, the more active its molecules are, and the more infrared energy it emits. An infrared thermometer houses optics that collect the radiant infrared energy from the object and focus it onto a detector. The detector converts the energy into an electrical signal, which is amplified and displayed. An IR thermometer is strictly a passive device and will not effect the measured equipment as the IR energy comes into the device and is not emitted by the thermometer.

### What response time can I expect from an IR thermometer?

The response time of IR thermometers is faster than most thermometers; approximately 0.5 second.

### What is the maximum distance I can make measurements from the target?

This is a function of the optics in your thermometer. Use the distance-to-size ratio and the diameter of your target to determine the maximum distance you can be from the target. Most IR thermometers have a maximum measuring distance of approximately 100 feet (30 meters), depending on atmospheric conditions.

### What area does the IR thermometer measure?

It measures the average temperature of the surface within the measuring diameter.

### What is emissivity?

Emissivity is the ability of an object to emit or absorb energy. Perfect emitters have an emissivity of 1, emitting 100% of incident energy. An object with an emissivity of 0.8 will absorb 80% and reflect 20% of the incident energy. Emissivity may vary with temperature and spectral response (wavelength). Infrared thermometers will have difficulty taking accurate temperature measurements of shiny metal surfaces unless they can adjust for emissivity.

### How can the emissivity of an object be determined?

**Option 1:** First, measure the surface temperature of the object to be measured with a surface-type thermocouple probe. Measure the same surface with an IR thermometer, adjusting emissivity on the thermometer until the temperature readings on both the thermocouple and IR meters agree.

**Option 2:** For temperatures up to approximately 500°F (260°C), place a piece of regular masking tape on the object to be measured. Allow the tape to reach thermal equilibrium with the object. Using an IR thermometer with the emissivity set at 0.95, measure and note the temperature of the masking tape. Then, measure the surface temperature of the object. Adjust the emissivity until the temperature of the object is the same as that of the tape.

**Option 3:** Use our below reference table as a guide.

## Metal Emissivity table

Material(metal)	Temp degF (degC)	Emissivity
<b>Alloys</b>		
** 20-Ni, 24-CR, 55-FE, Oxid.	392 (200)	0.9
** 20-Ni, 24-CR, 55-FE, Oxid.	932(500)	0.97
** 60-Ni, 12-CR, 28-FE, Oxid.	518 (270)	0.89
** 60-Ni, 12-CR, 28-FE, Oxid.	1040 (560)	0.82
** 80-Ni, 20-CR, Oxidised	212 (100)	0.87
** 80-Ni, 20-CR, Oxidised	1112 (600)	0.87
** 80-Ni, 20-CR, Oxidised	2372 (1300)	0.89
<b>Aluminium</b>		
** Unoxidised	77 (25)	0.02
** Unoxidised	212 (100)	0.03
** Unoxidised	932 (500)	0.06
** Oxidised	390 (199)	0.11
** Oxidised	1110 (599)	0.19
** Oxidised at 599degC(1110degF)	390 (199)	0.11
** Oxidised at 599degC(1110degF)	1110 (599)	0.19
** Heavily Oxidised	200 (93)	0.2
** Heavily Oxidised	940 (504)	0.31
** Highly Polished	212 (100)	0.09
** Roughly Polished	212 (100)	0.18
** Commercial Sheet	212 (100)	0.09
** Highly Polished Plate	440 (227)	0.04
** Highly Polished Plate	1070 (577)	0.06
** Bright Rolled Plate	338 (170)	0.04
** Bright Rolled Plate	932 (500)	0.05
** Alloy A3003, Oxidised	600 (316)	0.4
** Alloy A3003, Oxidised	900 (482)	0.4
** Alloy 1100-0	200-800 (93-427)	0.05
** Alloy 24ST	75 (24)	0.09
** Alloy 24ST, Polished	75 (24)	0.09
** Alloy 75ST	75 (24)	0.11
** Alloy 75ST, Polished	75 (24)	0.08
Bismuth, Bright	176 (80)	0.34
Bismuth, Unoxidised	77 (25)	0.05
Bismuth, Unoxidised	212 (100)	0.06
<b>Brass</b>		
** 73% Cu, 27% Zn, Polished	476 (247)	0.03
** 73% Cu, 27% Zn, Polished	674 (357)	0.03
** 62% Cu, 37% Zn, Polished	494 (257)	0.03
** 62% Cu, 37% Zn, Polished	710 (377)	0.04
** 83% Cu, 17% Zn, Polished	530 (277)	0.03
** Matte	68 (20)	0.07
** Burnished to Brown Colour	68 (20)	0.4
** Cu-Zn, Brass Oxidised	392 (200)	0.61
** Cu-Zn, Brass Oxidised	752 (400)	0.6
** Cu-Zn, Brass Oxidised	1112 (600)	0.61
** Unoxidised	77 (25)	0.04
** Unoxidised	212 (100)	0.04
** Cadmium	77 (25)	0.02
<b>Carbon</b>		
** Lampblack	77 (25)	0.95
** Unoxidised	77 (25)	0.81
** Unoxidised	212 (100)	0.81
** Unoxidised	932 (500)	0.79
** Candle Soot	250 (121)	0.95
** Filament	500 (260)	0.95
** Graphitized	212 (100)	0.76
** Graphitized	572 (300)	0.75
** Graphitized	932 (500)	0.71
Chromium	100 (38)	0.08
Chromium	1000 (538)	0.26
Chromium, Polished	302 (150)	0.06
Cobalt, Unoxidised	932 (500)	0.13
Cobalt, Unoxidised	1832 (1000)	0.23
Columbium, Unoxidised	1500 (816)	0.19
Columbium, Unoxidised	2000 (1093)	0.24
<b>Copper</b>		
** Cuprous Oxide	100 (38)	0.87
** Cuprous Oxide	500 (260)	0.83
** Cuprous Oxide	1000 (538)	0.77
** Black, Oxidised	100 (38)	0.78
** Etched	100 (38)	0.09
** Matte	100 (38)	0.22
** Roughly Polished	100 (38)	0.07
** Polished	100 (38)	0.03
** Highly Polished	100 (38)	0.02
** Rolled	100 (38)	0.64
** Rough	100 (38)	0.74

''	Molten	1000 (538)	0.15
''	Molten	1970 (1077)	0.16
''	Molten	2230 (1221)	0.13
''	Nickel Plated	100-500 (38-260)	0.37
Dow Metal		0.4-600 (-18-316)	0.15
Gold			
''	Enamel	212 (100)	0.37
''	Plate (.0001)	''	''
''	Plate on .0005 Silver	200-750 (93-399)	.11-.14
''	Plate on .0005 Nickel	200-750 (93-399)	.07-.09
''	Polished	100-500 (38-260)	0.02
''	Polished	1000-2000 (538-1093)	0.03
Haynes Alloy C,			
''	Oxidised	600-2000 (316-1093)	.90-.96
Haynes Alloy 25,			
''	Oxidised	600-2000 (316-1093)	.86-.89
Haynes Alloy X,			
''	Oxidised	600-2000 (316-1093)	.85-.88
Inconel Sheet		1000 (538)	0.28
Inconel Sheet		1200 (649)	0.42
Inconel Sheet		1400 (760)	0.58
Inconel X, Polished		75 (24)	0.19
Inconel B, Polished		75 (24)	0.21
Iron			
''	Oxidised	212 (100)	0.74
''	Oxidised	930 (499)	0.84
''	Oxidised	2190 (1199)	0.89
''	Unoxidised	212 (100)	0.05
''	Red Rust	77 (25)	0.7
''	Rusted	77 (25)	0.65
''	Liquid	2760-3220 (1516-1771)	.42-.45
Cast Iron			
''	Oxidised	390 (199)	0.64
''	Oxidised	1110 (599)	0.78
''	Unoxidised	212 (100)	0.21
''	Strong Oxidation	40 (104)	0.95
''	Strong Oxidation	482 (250)	0.95
''	Liquid	2795 (1535)	0.29
Wrought Iron			
''	Dull	77 (25)	0.94
''	Dull	660 (349)	0.94
''	Smooth	100 (38)	0.35
''	Polished	100 (38)	0.28
Lead			
''	Polished	100-500 (38-260)	.06-.08
''	Rough	100 (38)	0.43
''	Oxidised	100 (38)	0.43
''	Oxidised at 1100	100 (38)	0.63
''	Gray Oxidised	100 (38)	0.28
Magnesium		100-500 (38-260)	.07-.13
Magnesium Oxide		1880-3140 (1027-1727)	.16-.20
Mercury		32 (0)	0.09
Mercury		77 (25)	0.1
Mercury		100 (38)	0.1
Mercury		212 (100)	0.12
Monel, Ni-Cu		392 (200)	0.41
Monel, Ni-Cu		752 (400)	0.44
Monel, Ni-Cu		1112 (600)	0.46
Monel, Ni-Cu Oxidised		68 (20)	0.43
Monel, Ni-Cu Oxid. at 1110degF		1110 (599)	0.46
Nickel			
''	Polished	100 (38)	0.05
''	Oxidised	100-500 (38-260)	.31-.46
''	Unoxidised	77 (25)	0.05
''	Unoxidised	212 (100)	0.06
''	Unoxidised	932 (500)	0.12
''	Unoxidised	1832 (1000)	0.19
''	Electrolytic	100 (38)	0.04
''	Electrolytic	500 (260)	0.06
''	Electrolytic	1000 (538)	0.1
''	Electrolytic	2000 (1093)	0.16
Nickel Oxide		1000-2000 (538-1093)	.59-.86
Palladium Plate (.00005 on .0005 silver)		200-750 (93-399)	.16-.17
Platinum		100 (38)	0.05
Platinum		500 (260)	0.05
Platinum		1000 (538)	0.1
Platinum, Black		100 (38)	0.93

Platinum, Black		500 (260)	0.96
Platinum, Black		2000 (1093)	0.97
Platinum Oxidised at 1100		500 (260)	0.07
Platinum Oxidised at 1100		1000 (538)	0.11
Rhodium Flash (0.0002 on 0.0005 Ni)		200-700 (93-371)	.10-.18
Silver			
''	Plate (0.0005 on Ni)	200-700 (93-371)	.06-.07
''	Polished	100 (38)	0.01
''	Polished	500 (260)	0.02
''	Polished	1000 (538)	0.03
''	Polished	2000 (1093)	0.03
Steel			
''	Cold Rolled	200 (93)	.75-.85
''	Ground Sheet	1720-2010 (938-1099)	.55-.61
''	Polished Sheet	100 (38)	0.07
''	Polished Sheet	500 (260)	0.1
''	Polished Sheet	1000 (538)	0.14
''	Mild Steel, Polished	75 (24)	0.1
''	Mild Steel, Smooth	75 (24)	0.12
''	Mild Steel, liquid	2910-3270 (1599-1793)	0.28
''	Steel, Unoxidised	212 (100)	0.08
''	Steel, Oxidised	77 (25)	0.8
Steel Alloys			
''	Type 301, Polished	75 (24)	0.27
''	Type 301, Polished	450 (232)	0.57
''	Type 301, Polished	1740 (949)	0.55
''	Type 303, Oxidised	600-2000 (316-1093)	.74-.87
''	Type 310, Rolled	1500-2100 (816-1149)	.56-.81
''	Type 316, Polished	75 (24)	0.28
''	Type 316, Polished	450 (232)	0.57
''	Type 316, Polished	1740 (949)	0.66
''	Type 321	200-800 (93-427)	.27-.32
''	Type 321 Polished	300-1500 (149-815)	.18-.49
''	Type 321 w/BK Oxide	200-800 (93-427)	.66-.76
''	Type 347, Oxidised	600-2000 (316-1093)	.87-.91
''	Type 350	200-800 (93-427)	.18-.27
''	Type 350 Polished	300-1800 (149-982)	.11-.35
''	Type 446, Polished	300-1500 (149-815)	.15-.37
''	Type 17-7 PH	200-600 (93-316)	.44-.51
''	Type 17-7 PH Polished	300-1500 (149-815)	.09-.16
''	Type C1020, Oxidised	600-2000 (316-1093)	.87-.91
''	Type PH-15-7 MO	300-1200 (149-649)	.07-.19
Stellite, Polished		68 (20)	0.18
Tantalum, Unoxidised		1340 (727)	0.14
Tantalum, Unoxidised		2000 (1093)	0.19
Tantalum, Unoxidised		3600 (1982)	0.26
Tantalum, Unoxidised		5306 (2930)	0.3
Tin, Unoxidised		77 (25)	0.04
Tin, Unoxidised		212 (100)	0.05
Tinned Iron, Bright		76 (24)	0.05
Tinned Iron, Bright		212 (100)	0.08
Titanium			
''	Alloy C110M, Polished	300-1200 (149-649)	.08-.19
''	Oxidised at 538degC(1000degF)	200-800 (93-427)	.51-.61
''	Alloy Ti-95A, Oxidised at 538degC(1000degF)	200-800 (93-427)	.35-.48
''	Anodized onto SS	200-600 (93-316)	.96-.82
Tungsten			
''	Unoxidised	77 (25)	0.02
''	Unoxidised	212 (100)	0.03
''	Unoxidised	932 (500)	0.07
''	Unoxidised	1832 (1000)	0.15
''	Unoxidised	2732 (1500)	0.23
''	Unoxidised	3632 (2000)	0.28
''	Filament (Aged)	100 (38)	0.03
''	Filament (Aged)	1000 (538)	0.11
''	Filament (Aged)	5000 (2760)	0.35
Uranium Oxide		1880 (1027)	0.79
Zinc			
''	Bright, Galvanised	100 (38)	0.23
''	Commercial 99.1%	500 (260)	0.05
''	Galvanised	100 (38)	0.28
''	Oxidised	500-1000 (260-538)	0.11
''	Polished	100 (38)	0.02
''	Polished	500 (260)	0.03
''	Polished	1000 (538)	0.04
''	Polished	2000 (1093)	0.06

## Non-Metal Emissivity table

Material(Non-Metals)	Temp degF(degC)	Emissivity
Adobe	68 (20)	0.9
Asbestos		
Board	100 (38)	0.96
Cement	32-392 (0-200)	0.96
Cement, Red	2500 (1371)	0.67
Cement, White	2500 (1371)	0.65
Cloth	199 (93)	0.9
Paper	100-700 (38-371)	0.93
Slate	68 (20)	0.97
Asphalt, pavement	100 (38)	0.93
Asphalt, tar paper	68 (20)	0.93
Basalt	68 (20)	0.72
Brick		
Red, rough	70 (21)	0.93
Gault Cream	2500-5000 (1371-2760)	.26-.30
Fire Clay	2500 (1371)	0.75
Light Buff	1000 (538)	0.8
Lime Clay	2500 (1371)	0.43
Fire Brick	1832 (1000)	.75-.80
Magnesite, Refractory	1832 (1000)	0.38
Grey Brick	2012 (1100)	0.75
Silica, Glazed	2000 (1093)	0.88
Silica, Unglazed	2000 (1093)	0.8
Sandlime	2500-5000 (1371-2760)	.59-.63
Carborundum	1850 (1010)	0.92
Ceramic		
Alumina on Inconel	800-2000 (427-1093)	.69-.45
Earthenware, Glazed	70 (21)	0.9
Earthenware, Matte	70 (21)	0.93
Greens No. 5210-2C	200-750 (93-399)	.89-.82
Coating No. C20A	200-750 (93-399)	.73-.67
Porcelain	72 (22)	0.92
White Al2O3	200 (93)	0.9
Zirconia on Inconel	800-2000 (427-1093)	.62-.45
Clay		
Fired	158 (70)	0.91
Shale	68 (20)	0.69
Tiles, Light Red	2500-5000 (1371-2760)	.32-.34
Tiles, Red	2500-5000 (1371-2760)	.40-.51
Tiles, Dark Purple	2500-5000 (1371-2760)	0.78
Concrete		
Rough	32-2000 (0-1093)	0.94
Tiles, Natural	2500-5000 (1371-2760)	.63-.62
Brown	2500-5000 (1371-2760)	.87-.83
Black	2500-5000 (1371-2760)	.94-.91
Cotton Cloth	68 (20)	0.77
Dolomite Lime	68 (20)	0.41
Emery Corundum	176 (80)	0.86
Glass		
Convex D	212 (100)	0.8
Convex D	600 (316)	0.8
Convex D	932 (500)	0.76
Nonex	212 (100)	0.82
Nonex	600 (316)	0.82
Nonex	932 (500)	0.78
Smooth	32-200(0-93)	.92-.94
Granite	70 (21)	0.45
Gravel	100 (38)	0.28
Gypsum	68 (20)	.80-.90
Ice, Smooth	32 (0)	0.97
Ice, Rough	32 (0)	0.98
Lacquer		
Black	200 (93)	0.96
Blue, on Al Foil	100 (38)	0.78
Clear, on Al Foil (2 coats)	200 (93)	.08-.09
Clear, on Bright Cu	200 (93)	0.66
Clear, on Tarnished Cu	200 (93)	0.64
Red, on Al Foil (2 coats)	100 (38)	.60-.74
White	200 (93)	0.95
White, on Al Foil (2 coats)	100 (38)	.69-.88
Yellow, on Al Foil (2 coats)	100 (38)	.57-.79
Lime Mortar	100-500 (38-260)	.90-.92
Limestone	100 (38)	0.95
Marble, White	100 (38)	0.95
Smooth, White	100 (38)	0.56
Polished Grey	100 (38)	0.75
Mica	100 (38)	0.75

Oil on Nickel		
0.001 Film	72 (22)	0.27
0.002 "	72 (22)	0.46
0.005 "	72 (22)	0.72
Thick "	72 (22)	0.82
Oil, Linseed		
On Al Foil, uncoated	250 (121)	0.09
On Al Foil, 1 coat	250 (121)	0.56
On Al Foil, 2 coats	250 (121)	0.51
On Polished Iron, .002 Film	100 (38)	0.22
On Polished Iron, .002 Film	100 (38)	0.45
On Polished Iron, .004 Film	100 (38)	0.65
On Polished Iron, Thick Film	100 (38)	0.83
Paints		
Blue, Cu2O3	75 (24)	0.94
Black, CuO	75 (24)	0.96
Green, Cu2O3	75 (24)	0.92
Red, Fe2O3	75 (24)	0.91
White, Al2O3	75 (24)	0.94
White, Y2O3	75 (24)	0.9
White, ZnO	75 (24)	0.95
White, MgCO3	75 (24)	0.91
White, ZrO2	75 (24)	0.95
White, ThO2	75 (24)	0.9
White, MgO	75 (24)	0.91
White, PbCO3	75 (24)	0.93
Yellow, PbO	75 (24)	0.9
Yellow, PbCrO4	75 (24)	0.93
Paints, Aluminium	100 (38)	.27-.67
10% Al	100 (38)	0.52
26% Al	100 (38)	0.3
Dow XP-310	200 (93)	0.22
Paints, Bronze	Low	.34-.80
Gum Varnish (2 coats)	70 (21)	0.53
Gum Varnish (3 coats)	70 (21)	0.5
Cellulose Binder (2 coats)	70 (21)	0.34
Paints, Oil		
All colours	200 (93)	.92-.96
Black	200 (93)	0.92
Black Gloss	70 (21)	0.9
Camouflage Green	125 (52)	0.85
Flat Black	80 (27)	0.88
Flat White	80 (27)	0.91
Grey-Green	70 (21)	0.95
Green	200 (93)	0.95
Lamp Black	209 (98)	0.96
Red	200 (93)	0.95
White	200 (93)	0.94
Red Lead	212 (100)	0.93
Rubber, Hard	74 (23)	0.94
Rubber, Soft, Grey	76 (24)	0.86
Sand	68 (20)	0.76
Sandstone	100 (38)	0.67
Sandstone, Red	100 (38)	.60-.83
Sawdust	68 (20)	0.75
Shale	68 (20)	0.69
Silica, Glazed	1832 (1000)	0.85
Silica, Unglazed	2012 (1100)	0.75
Silicon Carbide	300-1200 (149-649)	.83-.96
Silk Cloth	68 (20)	0.78
Slate	100 (38)	.67-.80
Snow, Fine Particles	20 (-7)	0.82
Snow, Granular	18 (-8)	0.89
Soil		
Surface	100 (38)	0.38
Black Loam	68 (20)	0.66
Plowed Field	68 (20)	0.38
Soot		
Acetylene	75 (24)	0.97
Camphor	75 (24)	0.94
Candle	250 (121)	0.95
Coal	68 (20)	0.95
Stonework	100 (38)	0.93
Water	100 (38)	0.67
Wood	Low	.80-.90
Beech Planed	158 (70)	0.94
Oak, Planed	100 (38)	0.91
Spruce, Sanded	100 (38)	0.89