

TABLE OF EMISSIVITY OF VARIOUS SURFACES

Introduction:

Emissivity is a modifying factor used in single color thermometry to achieve a correct temperature reading. Emissivity, or radiating efficiency, of most materials is function of surface condition, temperature and wavelength of measurement.

In the following table, values for the total emissivity of various surfaces, as well as spectral emissivity at a given temperature, have been tabulated. Total emissivity is defined as the resultant value when the individual emissivity factors are averaged over the total radiation spectrum being utilized.

The user may find that for the application a different emissivity setting is required than the one tabulated. This table, however, will provide the best initial setting. A more refined value should be determined experimentally.

References:

- 1) *Handbook of Chemistry and Physics*, Chemical Rubber Publishing Co., Cleveland, Ohio
- 2) *DMIC Report 177*, Battelle Memorial Institute
- 3) *Thermal Radiation Properties Survey*, Honeywell Research Center

Mikron Instrument Company, Inc.
16 Thornton Road, Oakland NJ, 07436, USA
sales@mikroninst.com
www.mikroninst.com

Material	Temperature °C	*Emissivity
Alloys		
20Ni-25Cr-55Fe, oxidized.....	200	0.90
.....	500	0.97
60Ni-12Cr-28Fe, oxidized.....	270	0.89
.....	560	0.82
80Ni-20Cr, oxidized.....	100	0.87
.....	600	0.87
.....	1300	0.89
Aluminum		
Polished.....	100	0.095
Highly Polished	50-500	0.04-0.06
Unoxidized	25	0.022
.....	100	0.028
.....	500	0.060
Oxidized.....	200	0.11
.....	600	0.19
Commercial Sheet.....	100	0.090
Anodized Sheet, Chromic Acid Proc.....	100	0.55
Heavily Oxidized.....	93-504	0.2-0.31
Aluminum Oxide.....	500-827	0.42-0.26
Asbestos		
Board.....	20	0.96
Cement.....	0-200	0.96
Cloth.....	93	0.90
Paper.....	0-100	0.95
Asphalt.....	Ambient.....	0.90-0.98
Oil, on polished metal		
.001" Thick	Ambient.....	0.27
.002" Thick	Ambient.....	0.46
.005" Thick	Ambient.....	0.72
Bismuth, Unoxidized.....	25	0.048
.....	100	0.061

*When range of values for temperature and emissivity are given, end points correspond and linear interpolation of emissivity is acceptable.

Brass		
Polished.....	200	0.03
Unoxidized	25	0.035
.....	100	0.035
Oxidized.....	200	0.61
.....	600	0.59
Rolled Sheet.....	20	0.06
Brick		
Building.....	1000	0.450
Red, rough, no gross irregularities.....	20	0.930
Grog, brick, glazed.....	1100	0.750
Silica brick.....	1000	0.80
.....	1100	0.85
Fire Brick.....	1000	0.750
Bronze, Polished.....	50	0.10
Carbon		
Filament.....	1000-1400	0.53
Graphite.....	0-3600	0.70-0.80
Lamp, black, water glass coating	20-400	0.96
Soot applied to solid.....	50-1000.....	0.96
Candle soot.....	97-270	0.952
Graphite, pressed, filed surface.....	250-510.....	0.980
Unoxidized	25	0.81
.....	100	0.81
.....	500	0.81
Carborundum 87SiC; 2.3 density.....	1010-1400	0.920-0.820
Ceramic		
Earthenware.....	20	0.90
Porcelain, Glazed.....	20	0.92
Refractory Black.....	93.....	0.94
Refractory White	93.....	0.90
Chromium		
Polished.....	50	0.10
.....	500-1000	0.28-0.38
Unoxidized	100	0.08
Oxidized.....	316	0.08
.....	482	0.18
.....	650	0.27
.....	816	0.36

*When range of values for temperature and emissivity are given, end points correspond and linear interpolation of emissivity is acceptable.

.....	982	0.66
Cobalt, Unoxidized	500	0.13
.....	1000	0.23
Columbium		
Polished.....	1500	0.19
.....	2000	0.24
Oxidized.....	816	0.73
.....	927	0.70
Concrete	0-100	0.94
Concrete Tiles.....	1000	0.630
Copper		
Commercial, Scoured to a shine	20	0.07
Calorized.....	100	0.26
Calorized, oxidized.....	200	0.18
.....	600	0.19
Plate, heated long time, covered with		
Thick oxide layer.....	25	0.78
Plate, heated at 600°C	200-600	0.570
Cuprous Oxide.....	800-1100	0.66-0.54
Polished.....	50-100	0.02-0.05
Oxidized.....	50	0.6-0.7
.....	200	0.60
.....	500	0.88
Unoxidized	100	0.02
.....	Liquid	0.15
Dow Metal	232-400	0.24-0.20
Enamel, white, fused on iron.....	19	0.900
Glass		
Smooth	0-200	0.95
.....	250-1000	0.87-0.72
.....	1100-1500	0.70-0.67
Fused Quartz.....	320	0.75
Covex D Glass.....	320	0.76
Nonex Glass.....	320	0.82
Pyrex.....	0-300	0.90
Gold		
Pure, highly polished	100	0.02
Carefully polished.....	200-600	0.02-0.03

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Unoxidized	100	0.02
.....	500	0.03
Enamel.....	100	0.37
Graphite.....	0-3600	0.70-0.80
Gypsum 0.02" thick on smooth Or blackened plate.....	20	0.93
Human Skin.....	36.7-37.2	0.985
Inconel		
Type X.....		0.550-0.780
Type B.....	450-1620	0.350-0.550
Iron		
Cast		
Oxidized.....	200-600.....	0.64-0.78
Strongly Oxidized.....	40	0.95
.....	250	0.95
Unoxidized	100	0.21
Polished.....	200	0.210
Newly turned	22	0.440
Turned and heated.....	882-990.....	0.600-0.700
Liquid Unoxidized.....		0.29
Rusted.....	25	0.65
Wrought, dull.....	100	0.50
Wrought iron, dull oxidized.....	21-360	0.940
Wrought, highly polished.....	38-250	0.280
Oxidized.....	100	0.74
.....	500	0.84
Unoxidized	1200	0.89
Plate, pickled, then rusted red.....	20	0.610
Plate, completely rusted.....	19	0.690
Smooth oxidized electrolytic iron.....	127-527	0.780-0.820
Iron oxide	500-1200	0.85-0.89
Rough-ingot iron.....	927-1116	0.870-0.950
Cast Plate, oxidized, smooth.....	23	0.8
Cast Plate, oxidized, rough.....	23	0.82
Molten pure iron.....	1516-1771	0.420-0.450
Molten Armco iron.....	1521-1689	0.400-0.410

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Lead		
Pure (99.96%) Unoxidized	127-227	0.057-0.075
Oxidized	200	0.63
Oxidized, Gray.....	24	0.280
Magnesium		
Magnesium Oxide.....	227-826.....	0.550-0.200
Magnesium Oxide.....	900-1704	0.200
Magnesite		
Refractory Brick	1000	0.380
Marble, light grey polished		
	0-100.....	0.903
Mercury, Unoxidized.....		
	0.....	0.09
	25	0.10
	100	0.12
Molybdenum		
Polished.....	538	0.05
	1482	0.17
Oxidized.....	538	0.82
Unoxidized	1000	0.13
	1500	0.19
	2000	0.24
Filament.....	827-2593	0.096-0.202
Monel metal, Oxidized		
	200	0.43
	600	0.43
Nichrome Wire		
Clean.....	50	0.65
	500-1000	0.71-0.79
Oxidized.....	50-500	0.95-0.98
Nickel		
Polished.....	low.....	0.12
	1204	0.32
Oxidized.....	200	0.37
	871	0.85
	1200	0.85
Unoxidized	25	0.045
	100	0.06
	500	0.12
	1000	0.19

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Electroplated, Polished.....	23.....	0.045
Electroplated, not polished.....	20.....	0.110
Wire.....	187-1007.....	0.096-0.186
Plate, oxidized by heating at 600°C.....	200-600.....	0.370-0.480
Nickel Oxide.....	650-1254.....	0.590-0.860
Chromnickel.....	52-1034.....	0.640-0.760
Nickel-Silver Polished.....	100.....	0.135
Oak, Planed.....	21.....	0.900
Oil Layers on Aluminum foil		
(Linseed Oil)		
Aluminum foil.....	100.....	0.087
+1, 2 coats oil.....	100.....	0.561-0.574
Paint, Lacquers, Varnishes		
Alum. Paint.....	0-100.....	0.55
Bronze Paint.....	0-100.....	0.80
Black Glass Paint.....	0-100.....	0.90
White Lacquer.....	0-100.....	0.95
Green paint.....	0-100.....	0.95
Gray paint.....	0-100.....	0.95
Lamp black.....	0-100.....	0.95
Gold Enamel.....	0-100.....	0.37
Snow white enamel varnish on		
Rough iron plate.....	23.....	0.906
Black shiny lacquer, sprayed on iron.....	24.....	0.875
Black shiny shellac on tinned iron sheet.....	21.....	0.821
Black matte shellac.....	77-146.....	0.910
Black on white lacquer.....	38-93.....	0.800-0.950
Flat black lacquer.....	38-93.....	0.960-0.980
Oil paints, 16 diff (all colors).....	100.....	0.920-0.960
Aluminum paints & lacquers 10% A1 22%		
Lacquer body, on rough or smooth surface.....	100.....	0.270-0.670
A1 lacquer, varnish binder on rough plate.....	21.....	0.390
A1 paint after heating to 326°C.....	150-316.....	0.350
Radiator Paint		
White, Cream, Bleach.....	100.....	0.790,0.770
.....	0.840
Radiator Paint, bronze.....	100.....	0.510
Lacquer coatings, 0.001-0.015"		
Thick on alum. Alloys.....	38-150.....	0.870-0.970
3M Nextel 101-C10.....	0-300.....	0.97

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Mikron high temp test paint	ambient-650	0.93
Clear Silicone vehicle coating		
0.001-0.150" thick: on mild steels.....	260	0.660
On stainless steels 316, 301, 347	260	0.680,0.750
On dow metal	260	0.740
On A1 Alloys, 24ST, 75ST	260	0.770,0.820
Aluminum paint with silicone vehicle		
Paint on Inconel	260	0.290
Dull black varnish.....	40-100	0.80-0.95
Glossy black varnish sprayed on iron.....	20	0.87
.....	40	0.96-0.98
Paper, Any Color.....	0-100	0.94
Thinipasted on Tinned or Blackened Plate.....	19	0.920-0.940
Plaster	0-200	0.91
Plastics, Opaque any color.....	25	0.950
Platinum		
Cleaned Polished.....	200-600.....	0.05-0.10
Filament.....	27-1227	0.036-0.192
Unoxidized	25	0.037
.....	100	0.047
.....	500	0.096
.....	1000	0.152
.....	1500	0.191
Wire	50-200	0.06-0.07
.....	500-1000	0.10-0.16
.....	1400	0.18
Propellant:		
Liquid Rocket engine	600-4500	0.900
Quartz		
Rough, fused.....	21	0.930
Glass, 1.98mm Thick.....	282-838.....	0.900-0.410
Glass, 6.88mm Thick.....	300-838.....	0.930-0.470
Opaque.....	300-838.....	0.920-0.680
Roofing Paper.....	21	0.910
Silica (98 Si O2, Fe-free) effect of grain size		
Microns 10 microns.....	1010-1566	0.420-0.330
70-600 microns	1010-1566	0.620-0.460

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Silver

Polished.....	100	0.052
Cleaned Polished.....	200-600.....	0.02-0.03
Unoxidized	100	0.02
.....	500	0.035

Stainless Steel 18-8

Buffed	20	0.160
Polished.....	93	0.16
.....	371	0.19
Oxidized.....	93-371	0.83

Stainless Steel 303.....316

Oxidized.....1093

Stainless Steel 304 (8Cr 18Ni) light silvery,
Rough, brown, after heating

After 42 hours of heating at 527°C.....

Stainless Steel 310 (25Cr, 20Ni) brown, splotted,

Oxidized from furnace service.....

Stainless Steel

Allegheny metal No. 4, polished

Allegheny metal No. 66, polished.....

Steel

Alloyed (8%Ni, 18%Cr).....

Aluminized.....

Dull Nickel Plated.....

Flat, Rough Surface

Cast, Polished.....

Calorized, Oxidized.....

.....

Sheet Steel, Ground.....

Sheet Steel, Rolled.....

Sheet Steel, Strong, Rough Oxide Layer.....

Sheet with Shiny layer of oxide.....

Oxidized.....

.....

.....

Unoxidized

Molten Steel.....

.....

Molten Mild Steel.....

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Molten Steel, various with 0.25-1.2% (slightly oxidized surfaces).....	1560-1710	0.270-0.390
Molten Steel, unoxidized.....	Liquid.....	0.280
Steel Plate, Rough.....	40	0.94
.....	400	0.97
.....	600	0.57
Tantalum		
Unoxidized	1500	0.21
.....	2000	0.26
Filament.....	1327-3000	0.190-0.310
Thorium Oxide.....	277-500.....	0.580-0.360
Tin		
Unoxidized	25	0.05
Commercial tin-plated sheet iron.....	100	0.070-0.080
Tungsten		
Filament, aged.....	27-3316	0.320-0.350
Filament.....	3316	0.390
Unoxidized	25	0.024
.....	100	0.032
.....	500	0.071
.....	1000	0.15
.....	1500	0.23
.....	2000	0.28
Turbojet Engine Operating	350-600.....	0.900
Water	Ambient.....	0.96
Wood		
Spruce, sanded.....	93	0.82
Oak, planed.....	0-200.....	0.89
Zinc		
Highly Polished	200-300.....	0.04-0.05
Unoxidized	300	0.05
Oxidized be heating at 399°C.....	399	0.110
Galvanized Sheet Iron, fairly bright	28	0.230
Galvanized sheet iron, gray oxidized.....	24	0.280
Zinc, galvanized sheet.....	100	0.210
Zirconium Silicate.....	238-500.....	0.920-0.800
.....	500-832	0.800-0.520

*When range of values for temperature and emissivity are given, end points correspond and linear interpolation of emissivity is acceptable.

TABLE I
Spectral Emissivities of
Materials, Surface Unoxidized

MATERIAL	EMISSIVITY AT .65 μ	
	<u>Solid State</u>	<u>Liquid State</u>
Beryllium	0.61	0.61
Carbon	0.80-0.93	
Chromium	0.34	0.39
Cobalt	0.36	0.37
Columbium	0.37	0.40
Copper	0.10	0.15
Erbium	0.55	0.38
Gold	0.14	0.22
Iridium	0.30	
Iron	0.35	0.37
Manganese	0.59	0.59
Molybdenum	0.37	0.40
Nickel	0.36	0.37
Palladium	0.33	0.37
Platinum	0.30	0.38
Rhodium	0.24	0.30
Silver	0.07	0.07
Tantalum	0.49	
Thorium	0.36	0.40
Titanium	0.63	0.65
Tungsten	0.43	
Uranium	0.54	0.34
Vanadium	0.35	0.32
Yttrium	0.35	0.35
Zirconium	0.32	0.30
Steel	0.35	0.37
Cast Iron	0.37	0.40
Constantan	0.35	
Monel	0.37	
Chromel P (90 Ni-10 Cr)	0.35	
80 Ni-20 Cr	0.35	
60 Ni-24 Fe-16 Cr	0.36	
Alumel (95 Ni; Bal. Al, Mn, Si)	0.37	
90 Pt-10 Rh	0.27	

*When range of values for temperature and emissivity are given, end points correspond and linear interpolation of emissivity is acceptable.

TABLE II
Spectral Emissivities of Oxides

MATERIAL	EMISSIVITY AT .65 μ	
	<u>Range of Observed Values</u>	<u>Probable Value of the Oxide Formed On Smooth Metal</u>
Aluminum Oxide	0.22 to 0.40	0.30
Beryllium Oxide	0.07 to 0.37	0.35
Cerium Oxide	0.58 to 0.80	
Chromium Oxide	0.60 to 0.80	0.70
Cobalt Oxide		0.75
Columbium Oxide	0.55 to 0.71	0.70
Copper Oxide	0.60 to 0.80	0.70
Iron Oxide	0.63 to 0.98	0.70
Magnesium Oxide	0.10 to 0.43	0.20
Nickel Oxide	0.85 to 0.96	0.90
Thorium Oxide	0.20 to 0.57	0.50
Tin Oxide	0.32 to 0.60	
Titanium Oxide		0.50
Uranium Oxide		0.30
Vanadium Oxide		0.70
Yttrium Oxide		0.60
Zirconium Oxide	0.18 to 0.43	0.40
Alumel (oxidized)		0.87
Cast Iron (oxidized)		0.70
Chromel P (90 Ni-10 Cr) (oxidized)		0.87
80 Ni-20 Cr (oxidized)		0.90
60 Ni-24 Fe-16 Cr (oxidized)		0.83
55 Fe-37.5 Cr-7.5 Al (oxidized)		0.78
70 Fe-23 Cr-5 Al-2 Co (oxidized)		0.75
Constantan (55 Cu-45 Ni) (oxidized)		0.84
Carbon Steel (oxidized)		0.80
Stainless Steel (18-8) (oxidized)		0.85
Porcelain	0.25 to 0.50	

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TABLE III
Additional Emissivities at $.65 \mu$

MATERIAL		TEMPERATURE (°C)	EMITTANCE	
			POLISHED SURFACE	COARSE SURFACE
STEEL	Not oxidized	100-1200	0.35	0.35
	Lightly oxidized	100-1200	0.45	0.5
	Severely oxidized	100-1200	0.8-0.95	0.8-0.95
	Molten	1500	0.38	0.38
COPPER	Not oxidized	100-1000	0.06	0.2
	Lightly oxidized	100-1000	0.4	0.5
	Severely oxidized	100-1000	0.8	0.8
	Molten	1080	0.15	0.15
LEAD	Not oxidized	50-300	0.3	0.4
	Lightly oxidized	50-300	0.4	0.55
	Severely oxidized	50-300	0.6-0.7	0.6-0.7
	Molten	330		
BRICK	White brick	1000	0.3	
	Sillimanite brick	1000	0.5-0.6	
	Silica brick	1000	0.45-0.75	

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