

Total Emissivity of Various Surfaces

MATERIAL	TEMPERATURE °C	EMISSIVITY	MATERIAL	TEMPERATURE °C	EMISSIVITY
COPPER (CONTINUED)			Unoxidized	1200	0.89
Polished	50 to 100	0.02 to 0.05	Plate, pickled, then rusted red	20	0.61
Oxidized	50	0.6 to 0.7	Plate, completely rusted	19	0.69
	200	0.60	Smooth oxidized		
	500	0.88	electrolytic iron	127 to 527	0.78 to 0.82
Unoxidized	100	0.02			
	Liquid	0.15	Iron Oxide	500 to 1200	0.85 to 0.89
DOW METAL	232 to 400	0.24 to 0.20	Rough to ingot iron	927 to 1116	0.87 to 0.95
ENAMEL			Cast Plate, oxidized, smooth	23	0.8
White, fused on Iron	19	0.900	Cast Plate, oxidized, rough	23	0.82
GLASS			Molten Pure Iron	1516 to 1771	0.42 to 0.45
Smooth	0 to 200	0.95			
	250 to 1000	0.87 to 0.72	Molten Armco Iron	1521 to 1689	0.40 to 0.41
	1100 to 1500	0.70 to 0.67			
Fused Quartz	320	0.75	LEAD		
Covex D Glass	320	0.76	Pure (99.96%) Unoxidized	127 to 227	0.057 to 0.075
Nonex Glass	320	0.82	Oxidized	200	0.63
Pyrex	0 to 300	0.90	Oxidized, Gray	24	0.28
GOLD			MAGNESIUM		
Pure, highly polished	100	0.02	Magnesium Oxide	227 to 826	0.55 to 0.20
Carefully Polished	200 to 600	0.02 to 0.03	Magnesium Oxide	900 to 1704	0.20
Unoxidized	100	0.02	MAGNESITE		
	500	0.03	Refractory Brick	1000	0.38
Enamel	100	0.37	Marble, Light Grey Polished	0 to 100	0.903
GRAPHITE	0 to 3600	0.70 to 0.80	Mercury, Unoxidized	0	0.09
GYPSUM				25	0.10
0.02" thick on smooth				100	0.12
or blackened plate	20	0.93	MOLYBDENUM		
HUMAN SKIN	36.7 to 37.2	0.985	Polished	538	0.05
INCONEL				1482	0.17
Type X	-	0.55 to 0.78	Oxidized	538	0.82
Type B	450 to 1620	0.35 to 0.55	Unoxidized	1000	0.13
IRON				1500	0.19
Cast				2000	0.24
Oxidized	200 to 600	0.64 to 0.78	Filament	827 to 2593	0.096 to 0.202
Strongly Oxidized	40	0.95	MONEL METAL		
	250	0.95	Oxidized	200	0.43
Unoxidized	100	0.21		600	0.43
Polished	200	0.21	NICHROME WIRE		
Newly Turned	22	0.44	Clean	50	0.65
Turned and Heated	882 to 990	0.60 to 0.70		500 to 1000	0.71 to 0.79
			Oxidized	50 to 500	0.95 to 0.98
Liquid Unoxidized	-	0.29	NICKEL		
Rusted	25	0.65	Polished	low	0.12
Wrought, dull	100	0.50		1204	0.32
Wrought Iron, dull oxidized	21 to 360	0.94	Oxidized	200	0.37
				871	0.85
Wrought, highly polished	38 to 250	0.28		1200	0.85
Oxidized	100	0.74	Unoxidized	25	0.045
	500	0.84		100	0.06
				500	0.12
				1000	0.19
			Electroplated, Polished	23	0.045

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NICKEL (CONTINUED)					
Electroplated, not Polished	20	0.11	On stainless steels 316, 301,347	260	0.66, 0.75, 0.75
Wire	187 to 1007	0.096 to 0.186	On Dow Metal	260	0.74
Plate, oxidized by heating at 600°C	200 to 600	0.37 to 0.48	On Al Alloys 24ST, 75ST	260	0.77, 0.82
Nickel Oxide	650 to 1254	0.59 to 0.86	Aluminum Paint with silicone vehicle paint on Inconel	260	0.29
Chromnickel	52 to 1034	0.64 to 0.76	Dull Black Varnish	40 to 100	0.80 to 0.95
NickeltoSilver Polished	100	0.135	Glossy Black Varnish sprayed on Iron	20	0.87
				40	0.96 to 0.98
OAK			PAPER		
Planed	21	0.90	Any Color	0 to 100	0.94
			Thinipasted on Tinned or Blackened Plate	19	0.92 to 0.94
OIL LAYERS ON ALUMINUM FOIL (Linseed Oil)			PLASTER		
Aluminum Foil	100	0.087		0 to 200	0.91
+1,2 coats oil	100	0.561 to 0.574	PLASTICS		
			Opaque, any color	25	0.95
PAINT, LACQUERS, VARNISHES			PLATINUM		
Aluminum Paint	0 to 100	0.55	Cleaned Polished	200 to 600	0.05 to 0.10
Bronze Paint	0 to 100	0.80	Filament	27 to 1227	0.036 to 0.192
Black Glass Paint	0 to 100	0.90	Unoxidized	25	0.037
White Lacquer	0 to 100	0.95		100	0.047
Green Paint	0 to 100	0.95		500	0.096
Gray Paint	0 to 100	0.95		1000	0.152
Lamp Black	0 to 100	0.95		1500	0.191
Gold Enamel	0 to 100	0.37	Wire	50 to 200	0.06 to 0.07
Snow White Enamel varnish on rough iron plate	23	0.906		500 to 1000	0.10 to 0.16
Black Shiny Lacquer, sprayed on iron	24	0.875		1400	0.18
Black Shiny shellac on tinned iron sheet	21	0.821	PROPELLANT		
Black Matte shellac	77 to 146	0.91	Liquid rocket engine	600 to 4500	0.90
Black on White Lacquer	38 to 93	0.80 to 0.95	QUARTZ		
Flat Black Lacquer	38 to 93	0.96 to 0.98	Rough, fused	21	0.93
Oil Paints, 16 diff. (all colors)	100	0.92 to 0.96	Glass, 1.98mm Thick	282 to 838	0.90 to 0.41
Aluminum Paints & Lacquers 10% Al 22% lacquer body, on rough or smooth surface	100	0.52	Glass, 6.88mm Thick	300 to 838	0.93 to 0.47
Other Al paints, varying age and Al content	100	0.27 to 0.67	Opaque	300 to 838	0.92 to 0.68
Al Lacquer, varnish binder on rough plate	21	0.39	ROOFING PAPER	21	0.91
Al Paint after heating to 326°C	150to316	0.35	SILICA		
Radiator Paint: White, Cream, Bleach	100	0.79, 0.77, 0.84	(98 SiO ₂ , Fetofree) effect of grain size, 10 microns	1010 to 1566	0.42 to 0.33
Radiator Paint, bronze Lacquer coatings, 0.001 to 0.015" thick on Alum alloys	38 to 150	0.87 to 0.97	70 to 600 microns	1010 to 1566	0.62 to 0.46
3M Nextel101toC10	0 to 300	0.98	SILVER		
Mikron High Temp Test Paint (Spirex SP102)	Ambientto650	0.999	Polished	100	0.052
Clear Silicone Vehicle Coating 0.001 to 0.150" thick: On mild steels	260	0.66	Cleaned Polished	200 to 600	0.02 to 0.03
			Unoxidized	100	0.02
				500	0.035

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MATERIAL	TEMPERATURE °C	EMISSIVITY	MATERIAL	TEMPERATURE °C	EMISSIVITY
STAINLESS STEEL 18-8			TANTALUM		
Buffed	20	0.16	Unoxidized	1500	0.21
Polished	93	0.16		2000	0.26
	371	0.19	Filament	1327 to 3000	0.19 to 0.31
Oxidized	93 to 371	0.83	Thorium Oxide	277 to 500	0.58 to 0.36
STAINLESS STEEL 303			TIN		
Oxidized	316	0.74	Unoxidized	25	0.05
	1093	0.87	Commercial tintoplated sheet iron	100	0.07 to 0.08
STAINLESS STEEL 304 (8CRI 18 Ni)			TUNGSTEN		
Light silvery, rough brown, after heating	216 to 490	0.44 to 0.36	Filament, aged	27 to 3316	0.32 to 0.35
After 42 hours of heating at 527°C	216 to 527	0.62 to 0.73	Filament	3316	0.39
STAINLESS STEEL 310 (25CR, 20Ni)			Unoxidized	25	0.024
Brown, splotched, oxidized from furnace service	216 to 527	0.90 to 0.97		100	0.032
				500	0.071
STAINLESS STEEL				1000	0.15
Allegheny metal No. 4, polished	100	0.130		1500	0.23
Allegheny metal No. 66, polished	100	0.110		2000	0.28
STEEL			TURBOJET ENGINE OPERATING	350 to 600	0.90
Alloyed (8%Ni, 18%Cr)	500	0.35	WATER	Ambient	0.96
Aluminized	50 to 500	0.79	WOOD		
Dull Nickel Plated	20	0.11	Spruce, sanded	93	0.82
Flat, rough surface	50	0.95 to 0.98	Oak, planed	0 to 200	0.89
Cast, polished	750 to 1050	0.52 to 0.56	ZINC		
Calorized, oxidized	200	0.52	Highly Polished	200 to 300	0.04 to 0.05
	600	0.57	Unoxidized	300	0.05
Sheet Steel, ground	938 to 1100	0.55 to 0.61	Oxidized by heating at 399°C	399	0.11
Sheet Steel, rolled	21	0.66	Galvanized Sheet Iron, fairly bright	28	0.23
Sheet Steel, strong, rough Oxide Layer	24	0.80	Galvanized Sheet Iron, gray oxidized	24	0.28
Sheet with shiny layer of oxide	20	0.82	Zinc, galvanized sheet	100	0.21
Oxidized	25	0.80	ZIRCONIUM SILICATE	238 to 500	0.92 to 0.80
	200	0.79		500 to 832	0.80 to 0.52
	600	0.79			
Unoxidized	100	0.08			
Molten Steel	1500 to 1650	0.42 to 0.53			
	1520 to 1650	0.43 to 0.40			
Molten Mild Steel	1600 to 1800	0.28			
Molten Steel, various with 0.25 to 1.2%C (slightly oxidized surfaces)	1560 to 1710	0.27 to 0.39			
Molten Steel, unoxidized	Liquid	0.28			
Steel Plate, rough	40	0.94			
	400	0.97			
	600	0.57			

MATERIAL	EMISSION AT .65μ	
	Solid State	Liquid State
Beryllium	0.61	0.61
Carbon	0.80 to 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	0.35
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	

MATERIAL	EMISSION AT 65μ	
	Range of Observed Values	Probable Value of the Oxide Formed on Smooth Metal
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 Dr-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	0.025 to 0.50	

Material	Temperature °C	Emittance		Material	Temperature °C	Emittance			
		Polished Surface	Coarse Surface			Polished Surface	Coarse Surface		
STEEL	Not oxidized	100 to 1200	0.35	0.35	ZINC	Not oxidized	20 to 400	0.2	0.3
	Lightly oxidized	100 to 1200	0.45	0.5		Lightly oxidized	20 to 400	0.3	0.5
	Severely oxidized	100 to 1200	0.8 to 0.95	0.8 to 0.95		Severely oxidized	20 to 400	0.6	0.6
	Molten	1500	0.38	0.38	ALUMINA		1500	0.2 to 0.4	
COPPER	Not oxidized	100 to 1000	0.06	0.2	ALUMINUM	Not oxidized	25 to 600	0.05	0.25
	Lightly oxidized	100 to 1000	0.4	0.5		Lightly oxidized	25 to 600	0.2	0.3
	Severely oxidized	100 to 1000	0.8	0.8		Severely oxidized	25 to 600	0.4	0.4
	Molten	1080	0.15	0.15		Molten	660		
LEAD	Not oxidized	50 to 300	0.3	0.4	GOLD	Not oxidized	100 to 1000	0.04	0.15
	Lightly oxidized	50 to 300	0.4	0.55		Molten	1100		
	Severely oxidized	50 to 300	0.6 to 0.7	0.6 to 0.7	CERAMIC	100 to 1200	0.25		
	Molten	330				1500	0.3		
				1800		0.4			
BRICK	White Brick	1000	0.3						
	Sillimanite Brick	1000	0.5 to 0.6						
	Silica Brick	1000	0.45 to 0.75						

Temperature Errors Caused By 1% Emissivity Change

The magnitude of temperature error created by a given emissivity uncertainty depends on the spectral range of the infrared thermometer, and the temperature of the target. The error table shows temperature errors caused by a 1% emissivity error, for different spectral bands at different target temperatures. The error is given in degrees Celsius. For 2-color instruments with spectral response Code R, 1% change represents change in the ratio of emissivities.

SPECTRAL RESPONSE CODE											
Mikron's Spectral Code	V	H	Q	P	M	D	L	E	F	B	R
Effective Wavelength	0.65µm	0.9µm	1.64µm	2.3µm	3.43µm	3.86µm	4.5µm	5.0µm	7.9µm	10.6µm	0.78-1.06
Target Temperature (°C)	Errors (°C)										
-50.0									1.8	1.3	
-40.0									1.3	1.0	
-30.0									1.0	0.8	
-20.0									0.7	0.6	
-10.0									0.5	0.4	
0.0									0.3	0.3	
10.0									0.2	0.2	
20.0									0.0	0.0	
30.0					0.0	0.0	0.0	0.0	0.0	0.0	
40.0					0.1	0.1	0.1	0.1	0.1	0.1	
50.0				0.1	0.2	0.2	0.2	0.2	0.2	0.2	
60.0				0.2	0.2	0.2	0.2	0.2	0.3	0.3	
70.0				0.2	0.2	0.3	0.3	0.3	0.4	0.4	
80.0				0.2	0.3	0.3	0.3	0.3	0.4	0.5	
90.0				0.2	0.3	0.3	0.3	0.4	0.5	0.5	
100.0			0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	
120.0			0.2	0.3	0.4	0.4	0.4	0.5	0.6	0.7	
140.0			0.2	0.3	0.4	0.4	0.5	0.5	0.8	0.9	
160.0			0.2	0.3	0.4	0.5	0.6	0.6	0.9	1.0	
180.0			0.2	0.3	0.5	0.5	0.6	0.7	1.0	1.1	
200.0			0.3	0.4	0.5	0.6	0.7	0.8	1.1	1.2	
220.0			0.3	0.4	0.6	0.7	0.7	0.8	1.2	1.4	
240.0			0.3	0.4	0.6	0.7	0.8	0.9	1.3	1.5	
260.0			0.3	0.5	0.7	0.8	0.9	1.0	1.4	1.6	
280.0			0.4	0.5	0.7	0.8	0.9	1.0	1.5	1.8	
300.0			0.4	0.5	0.8	0.9	1.0	1.1	1.6	1.9	
320.0			0.4	0.6	0.8	0.9	1.1	1.2	1.8	2.0	
340.0			0.4	0.6	0.9	1.0	1.2	1.3	1.9	2.2	
360.0			0.5	0.7	1.0	1.1	1.2	1.4	2.0	2.3	
380.0			0.5	0.7	1.0	1.1	1.3	1.4	2.1	2.4	
400.0		0.3	0.5	0.7	1.1	1.2	1.4	1.5	2.2	2.6	
420.0		0.3	0.5	0.8	1.2	1.3	1.5	1.6	2.4	2.7	
440.0		0.4	0.6	0.8	1.2	1.4	1.6	1.7	2.5	2.9	
460.0		0.4	0.6	0.9	1.3	1.4	1.7	1.8	2.6	3.0	
480.0		0.4	0.6	0.9	1.4	1.5	1.7	1.9	2.8	3.2	
500.0		0.4	0.7	1.0	1.4	1.6	1.8	2.0	2.9	3.3	
550.0		0.5	0.7	1.1	1.6	1.8	2.1	2.3	3.2	3.7	
600.0		0.5	0.8	1.2	1.8	2.0	2.3	2.5	3.6	4.1	10.6
650.0		0.6	0.9	1.4	2.0	2.3	2.6	2.8	4.0	4.5	11.2
700.0		0.6	1.0	1.5	2.2	2.5	2.8	3.1	4.3	4.9	11.7
750.0		0.7	1.1	1.7	2.5	2.8	3.1	3.4	4.7	5.3	12.2
800.0	0.5	0.8	1.2	1.8	2.7	3.0	3.4	3.7	5.1	5.7	12.8
850.0	0.6	0.8	1.3	2.0	3.0	3.3	3.7	4.0	5.5	6.1	13.4
900.0	0.6	0.9	1.4	2.2	3.2	3.5	4.0	4.3	5.9	6.5	14.0
950.0	0.7	1.0	1.5	2.4	3.5	3.8	4.3	4.7	6.3	6.9	14.6
1000.0	0.7	1.1	1.7	2.5	3.7	4.1	4.6	5.0	6.7	7.4	15.3
1100.0	0.9	1.3	1.9	2.9	4.3	4.7	5.3	5.7	7.5	8.2	16.7
1200.0	1.0	1.4	2.2	3.4	4.9	5.4	6.0	6.4	8.4	9.1	18.1
1300.0	1.1	1.6	2.4	3.8	5.5	6.0	6.7	7.2	9.2	10.0	19.7
1400.0	1.3	1.8	2.7	4.3	6.2	6.7	7.4	7.9	10.1	10.9	21.3
1500.0	1.4	2.0	3.0	4.8	6.8	7.4	8.1	8.7	11.0	11.9	23.1
1600.0	1.6	2.3	3.4	5.3	7.5	8.1	8.9	9.5	11.9	12.7	24.9
1700.0	1.8	2.5	3.7	5.8	8.2	8.9	9.7	10.3	12.8	13.7	26.8
1800.0	1.9	2.8	4.0	6.4	8.9	9.6	10.5	11.1	13.7	14.6	28.8
1900.0	2.1	3.0	4.4	7.0	9.6	10.4	11.3	12.0	14.6	15.5	30.9
2000.0	2.3	3.3	4.8	7.6	10.4	11.2	12.1	12.8	15.5	16.5	33.1
2100.0	2.5	3.6	5.2	8.2	11.2	12.0	12.9	13.6	16.4	17.4	35.4
2200.0	2.8	3.9	5.6	8.8	12.0	12.7	13.8	14.5	17.3	18.3	37.8
2300.0	3.0	4.2	6.0	9.5	12.7	13.6	14.6	15.3	18.3	19.3	40.2
2400.0	3.2	4.5	6.4	10.1	13.5	14.4	15.5	16.2	19.2	20.3	42.7
2500.0	3.5	4.9	6.9	10.8	14.3	15.2	16.3	17.1	20.2	21.2	45.4
2600.0	3.7	5.2	7.3	11.5	15.1	16.1	17.2	18.0	21.1	22.2	48.1
2700.0	4.0	5.6	7.8	12.2	15.9	16.9	18.1	18.9	22.1	23.1	50.9
2800.0	4.2	5.9	8.3	12.8	16.8	17.8	19.0	19.8	23.0	24.1	53.8
2900.0	4.5	6.3	8.8	13.6	17.6	18.6	19.9	20.7	24.0	25.1	56.8
3000.0	4.8	6.7	9.3	14.3	18.4	19.5	20.7	21.6	24.9	26.0	59.9