THERMO-OPTICAL PROPERTIES

Thermo-optical properties of common substances in bulk are compiled in Table 1. Table 2 gives a more detailed and specific compilation for typical thermal control surfaces used in spacecraft thermal design, where different values for beginning-of-life conditions and end-of-life conditions are given to account for in-orbit degradation (e.g. by atomic oxygen and oxygen ion chemical attack). In all cases, the two-spectral-band model (explained in Heat transfer and thermal modelling) is assumed.

Table 1. Thermo-optic properties of some common materials (at 288 K).

Substance	Solar absorptance (normal) α	Emissivity (hemispherical, bolometric) ε
Alumina	0.1..0.25	0.3..0.5
Aluminium	0.1..0.15 [a]	0.05[a]
Bakelite	0.9	0.94
Beryllium[b]	0.5..0.7	0.18
Brass		0.03..0.1
Copper	0.2..0.5	0.05
Cork		0.7
Elastomer		0.9
Glass (pyrex)		0.9
Glass (quartz)		0.93
Glass (window)	0.1	0.9
Ice	0.3..0.5	0.92
Iron (cast-)	0.3	0.2..0.7
Magnesium		0.2..0.5
Methacrylate		0.9
Nickel	0.2	0.05
Paper	0.3	0.95
Platinum		0.09
Polyethylene[b]		0.9
Polystyrene[b]		0.9
Polyurethane[b]		0.9
PVC[a]		0.9
Sand & soil	0.4..0.7	0.5..0.8
Silicon	0.7	0.3
Silver		0.02
Steel (carbon-)	0.2	0.2..0.6
Steel (stainless-)	0.4	0.2..0.3
Teflon (PTFE)	0.12	0.85
Titanium	0.4..0.7	0.2..0.5
Wolfram	0.45	0.09

a) Aluminium absorptance and emissivity may vary a lot. Emissivity ranges from ε=0.05 if polished, to ε=0.80 if hard anodised (or dew-covered), or even ε=0.85 if black anodised (e.g. integral anodised and pore-filling with a cobalt sulfide precipitate, CoS, from solutions). Solar absorptance may vary from α=0.09 if polished to α=0.90 if black anodised (if anodised only, α=0.40). Aluminium foil gets hot under sunshine because α/ε=0.15/0.05>1). Aluminium paint may have ε=0.3 when bright and ε=0.6 when dull.

b) Emissivity of thin plastic films is much lower than the quoted bulk value (e.g. for 0.1 mm films, ε=0.15 for polyethylene and ε=0.60 for PVC).

Table 2. Thermo-optic properties of typical spacecraft surfaces (at 288 K).

	BOL (Beginning of life)			EOL (End of life)		
Surface	Solar absorptance, α	Emissivity, ε	α/ε	Solar absorptance, α	Emissivity, ε	α/ε
Aluminium anodised (structures)	0.20	0.60	0.33	0.80	0.80	1.00
Aluminium (vessels)	0.15	0.20	0.75	0.10	0.10	1.00
Aluminised kapton (al. inside)	0.40	0.80	0.50	0.40	0.80	0.50
Aluminised kapton (al. outside)	0.15	0.05	3.0	0.15	0.05	3.0
Beta cloth	0.30	0.85	0.35	0.40	0.85	0.47
Black paint (insides)	0.90	0.90	1.00	0.90	0.90	1.00
GFRP (solar panels, structures)	0.85	0.85	1.00	0.85	0.85	1.00
Goldised kapton (gold outside)	0.25	0.02	12	0.25	0.02	12
MLI (back aluminised kapton)	0.30	0.60	0.50	0.60	0.60	1.00
OSR (radiators)	0.08	0.80	0.10	0.08	0.80	0.10
Silver paint (electrically cond.)	0.35	0.45	0.78	0.50	0.60	0.83
Solar cells	0.75	0.75	1.00	0.85	0.85	1.00
Titanium tiodized* (apogee motor)	0.60	0.60	1.00	0.60	0.60	1.00
White paint (antenna)	0.20	0.85	0.24	0.60	0.85	0.71

*Tiodizing is a special anodizing process of titanium and its alloys that forms a Ti-oxidized protective surface.

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