COPY 2

Minnesota Forestry Research Notes

UNIVERSITY OF MINNESOTA
JUN 25 1974
FORESTRY LIBRARY

No. 249
April 15, 1974

Tabulated Values of the Stefan-Boltzman Function

Larry A. Drew[1/]

The Stefan-Boltzman function was proposed in the late 1800's. Stefan determined through experimentation that a body radiates in proportion to the fourth power of its absolute temperature; Boltzman later deduced the same idea on a thermodynamic basis (Planck, 1914). The function is written

$$R = \varepsilon \sigma T^4$$

where R is the intensity of radiation emitted from an object (calories cm^{-2} min^{-1}), ε is the emissivity of the object (ratio of its emission to that of a perfect blackbody), σ is a constant (8.132×10^{-11} cal cm^{-2} min^{-1} $°K^{-4}$ [List, 1966]), and T is the absolute temperature of the object (°K = °C + 273.15 [Weast, 1969]). The function is of use in two ways: if we wish to know the intensity of radiation emitted from an object we may measure its surface temperature; if we wish to know the radiative surface temperature of an object we may measure the emitted radiation. Since most objects are not perfect radiators (blackbodies) their emissivities are less than 1. For example, most natural surfaces with temperatures normally found in our environment have integrated emissivities of 0.90-0.99. Other surfaces may have very different emissivities (Kreith, 1965). The emissivities are integrated because most surfaces do not usually emit all wavelengths of radiation equally.

The Stefan-Boltzman function has been used in physics and engineering and more recently in ecology, hydrology and soils. The measurement of energy fluxes within and above plant communities, soils, water, organisms and parts of organisms are now common. Vegetation, animal, water or soil surface

---

1/ Lecturer, College of Forestry, University of Minnesota, St. Paul, Mn. 55108.

temperatures may be determined by use of the function; evaporation estimates are often based on application of the function. More recently it has been applied in the calibration and use of net radiometers which differentiate between downward and upward fluxes (Drew, 1973).

Often the need arises for the solution of the Stefan-Boltzman function when modern computational facilities are not available. Tabulated values of the function are then of use. Tanner and Robinson (1959) published values of the blackbody function (emissivity = 1.0) based on 0.2°C increments and Brown (1973) has published similar tables based on increments of 0.1°C; however, there are times, such as in a closed or stable atmosphere, when more precise temperature measurements are made or required. The tables published as a supplement to this note are meant to provide a field or desk aid in the solution of problems dealing with the Stefan-Boltzman function.

Emissivities of natural objects are difficult to determine and since most natural surfaces have emissivities near 1, this value is often assumed when the true emissivity is unknown. Stefan-Boltzman radiation with an emissivity of 1 is usually termed "blackbody radiation"; the function is illustrated in the graph shown below. The first supplemental table is of blackbody radiation (illustrated below) for a temperature range of -40.00° to +70.00° Celsius in hundredths of degree increments; values are given in langleys per minute (1 ly = 1 cal cm^{-2}) rounded to the fifth decimal place. Radiation from surfaces with emissivities less than 1 may be determined by multiplying the tabulated value by the appropriate emissivity. The second table is of Stefan-Boltzman radiation (illustrated below) for emissivities of 0.90 to 0.99 in increments of 0.01 and a temperature range of -20.0° to +60.0° Celsius for tenths of degree increments; values again are in langleys per minute rounded to the fifth decimal place. This table should provide a quick reference for most work.

Literature Cited

Brown, J. M. 1973. Tables and conversions for microclimatology. North Central Forest Exp. Sta., St. Paul, Mn. USDA Forest Serv. Gen. Tech. Rep. NC-8. 31p.

Drew, L. A. 1973. Vegetation-environment relationships in the prairie-forest transition zone in Minnesota. Ph.D. Thesis, University of Minnesota, Minneapolis. 405p.

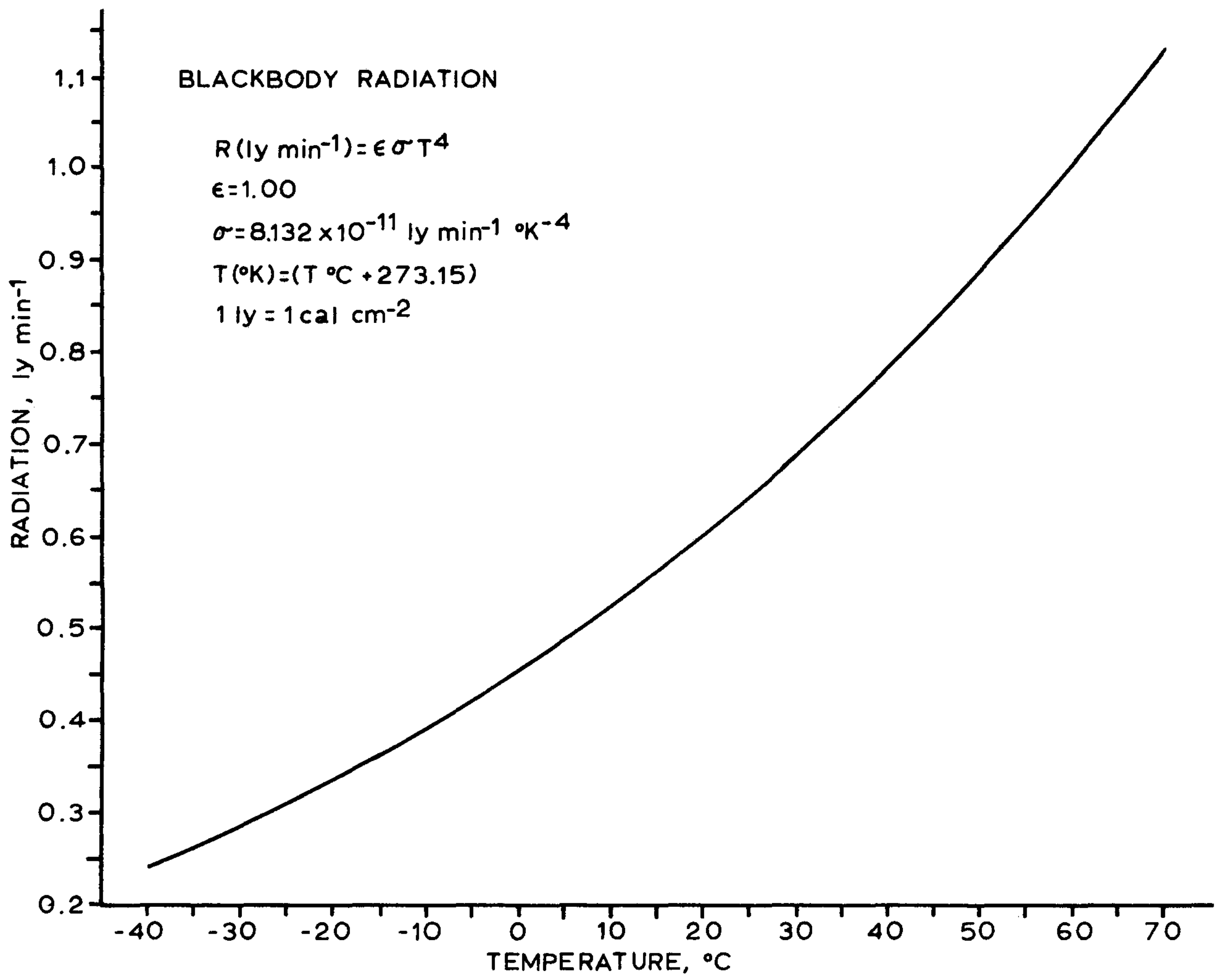
Kreith, F. 1965 (1967). Principles of heat transfer. Second edition. International Textbook Co., Scranton, Pennsylvania. 620p.

List, R. J. 1966. Smithsonian meteorological tables. 6th ed. Smithsonian Institution, Washington, D. C. Pub. 4014. 527 p.

Planck, M. 1914 (1959). The theory of heat radiation. Transl. by M. Masius. Dover Publications, Inc., New York. 224p.

Tanner, C. B. and S. M. Robinson. 1959. Black-body function, σT^4. Dept. Soils, College of Agric., Univ. Wisconsin, Madison. Soils Bull. 1. 45 p.

Weast, R. C., ed. 1969. Handbook of chemistry and physics. 50th ed. Chemical Rubber Co., Cleveland, Ohio. 2383p.


BLACKBODY RADIATION
R(ly min-1) = ε σ T4
ε = 1.00
σ = 8.132 x 10-11 ly min-1 °K-4
T(°K) = (T °C + 273.15)
1 ly = 1 cal cm-2
RADIATION, ly min-1
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
-40
-30
-20
-10
0
10
20
30
40
50
60
70
TEMPERATURE, °C

BLACKBODY RADIATION (LY/MIN) FOR HUNDREDTHS OF DEGREES CELSIUS

DEG C	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
10.0	.52271	.52279	.52286	.52293	.52301	.52308	.52316	.52323	.52330	.52338
10.1	.52345	.52353	.52360	.52367	.52375	.52382	.52390	.52397	.52404	.52412
10.2	.52419	.52427	.52434	.52441	.52449	.52456	.52464	.52471	.52478	.52486
10.3	.52493	.52501	.52508	.52515	.52523	.52530	.52538	.52545	.52553	.52560
10.4	.52567	.52575	.52582	.52590	.52597	.52604	.52612	.52619	.52627	.52634
10.5	.52642	.52649	.52656	.52664	.52671	.52679	.52686	.52694	.52701	.52708
10.6	.52716	.52723	.52731	.52738	.52746	.52753	.52760	.52768	.52775	.52783
10.7	.52790	.52798	.52805	.52812	.52820	.52827	.52835	.52842	.52850	.52857
10.8	.52865	.52872	.52879	.52887	.52894	.52902	.52909	.52917	.52924	.52932
10.9	.52939	.52947	.52954	.52961	.52969	.52976	.52984	.52991	.52999	.53006
11.0	.53014	.53021	.53029	.53036	.53044	.53051	.53058	.53066	.53073	.53081
11.1	.53088	.53096	.53103	.53111	.53118	.53126	.53133	.53141	.53148	.53156
11.2	.53163	.53171	.53178	.53186	.53193	.53201	.53208	.53215	.53223	.53230
11.3	.53238	.53245	.53253	.53260	.53268	.53275	.53283	.53290	.53298	.53305
11.4	.53313	.53320	.53328	.53335	.53343	.53350	.53358	.53365	.53373	.53380
11.5	.53388	.53395	.53403	.53410	.53418	.53425	.53433	.53440	.53448	.53455
11.6	.53463	.53470	.53478	.53485	.53493	.53500	.53508	.53515	.53523	.53530
11.7	.53538	.53546	.53553	.53561	.53568	.53576	.53583	.53591	.53598	.53606
11.8	.53613	.53621	.53628	.53636	.53643	.53651	.53658	.53666	.53673	.53681
11.9	.53689	.53696	.53704	.53711	.53719	.53726	.53734	.53741	.53749	.53756
12.0	.53764	.53771	.53779	.53787	.53794	.53802	.53809	.53817	.53824	.53832

STEFAN-BOLTZMAN RADIATION (LY/MIN) FOR EMISSIVITIES OF 0.90 TO 0.99 AND TENTHS OF DEGREES CELSIUS

	EMISSIVITY									
DEG C	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99
10.0	.47044	.47567	.48090	.48612	.49135	.49658	.50180	.50703	.51226	.51749
10.1	.47111	.47634	.48158	.48681	.49205	.49728	.50251	.50775	.51298	.51822
10.2	.47177	.47701	.48226	.48750	.49274	.49798	.50322	.50847	.51371	.51895
10.3	.47244	.47769	.48294	.48819	.49344	.49869	.50393	.50918	.51443	.51968
10.4	.47311	.47836	.48362	.48888	.49413	.49939	.50465	.50990	.51516	.52042
10.5	.47377	.47904	.48430	.48957	.49483	.50009	.50536	.51062	.51589	.52115
10.6	.47444	.47971	.48499	.49026	.49553	.50080	.50607	.51134	.51661	.52189
10.7	.47511	.48039	.48567	.49095	.49623	.50151	.50679	.51206	.51734	.52262
10.8	.47578	.48107	.48635	.49164	.49693	.50221	.50750	.51279	.51807	.52336
10.9	.47645	.48175	.48704	.49233	.49763	.50292	.50822	.51351	.51880	.52410
11.0	.47712	.48242	.48773	.49303	.49833	.50363	.50893	.51423	.51953	.52484
11.1	.47780	.48310	.48841	.49372	.49903	.50434	.50965	.51496	.52027	.52557
11.2	.47847	.48378	.48910	.49442	.49973	.50505	.51037	.51568	.52100	.52631
11.3	.47914	.48447	.48979	.49511	.50044	.50576	.51108	.51641	.52173	.52706
11.4	.47982	.48515	.49048	.49581	.50114	.50647	.51180	.51713	.52247	.52780
11.5	.48049	.48583	.49117	.49651	.50185	.50718	.51252	.51786	.52320	.52854
11.6	.48117	.48651	.49186	.49720	.50255	.50790	.51324	.51859	.52394	.52928
11.7	.48184	.48720	.49255	.49790	.50326	.50861	.51396	.51932	.52467	.53003
11.8	.48252	.48788	.49324	.49860	.50396	.50933	.51469	.52005	.52541	.53077
11.9	.48320	.48857	.49393	.49930	.50467	.51004	.51541	.52078	.52615	.53152
12.0	.48388	.48925	.49463	.50000	.50538	.51076	.51613	.52151	.52689	.53226

A copy of the supplemental tables may be obtained by writing to the College of Forestry, University of Minnesota, St. Paul, Minnesota 55108.

Published as Sci. Jour. Ser. Paper No. 8689 of the Univ. of Minn. Agr. Expt. Sta.