Evaluation of materials for

Livestock Shades

applicable to other open-type structures

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In animal environment investigations in the Imperial Valley the most economical means of reducing the heat stress of farm livestock during the summer months was provided by shades.

The primary purpose of a livestock shade is to reduce the radiation heat load on an animal. The radiation that causes the heat load comes, mainly, from three zones surrounding the animal—the sun, the sky, and the ground—and a shade reduces the amount of radiation from each source. The amount of reduction in radiant heat load depends on the design and the material used for the shade.

At Davis, 50 materials and combinations of materials were evaluated on the basis of the radiant heat load reduction under flat shades covered with the test materials. Each material was rated with an effectiveness value—E—showing the ratio of the reduction in radiant heat load by the material to that of the standard embossed corrugated aluminum roofing.

The test method devised allowed comparisons to be made without use of animals, and thus reduced the time and expense required to make an adequate evaluation. Four 8′ × 12′ frames were used to support the test materials 4′ above the ground. One frame was always covered with the standard aluminum roofing to provide a common basis for comparing tests at various locations or of different years. Six-inch black globe thermometers measured the radiant heat load 18″ above the ground at the center of the shadow of each shade. The 18″ height represented the approximate center of a standing hog. The unshaded enviroment was measured with a fifth globe thermometer.

With simultaneous values for air velocity and temperature near a black globe thermometer, and with the temperature of the globe, the radiant heat load at the globe can be calculated. This will approximate the quantity of radiation, in British thermal units per hour—Btu/hr—falling on each square foot of surface of an animal at the center of the shade's shadow.

During the tests the shades were located on disked ground with no vegetation. They were placed with the long axis east and west and spaced so there was a minimum of wind interference or radiation effects among the shades or surrounding objects. Observations were made at half-hour intervals on clear bright days from 10:00 a.m. to 3:00 p.m. during the hot summer months.

The difference in radiant heat loads indicated by globes in the sun and in the shade of a test material was divided by the amount of reduction indicated for the aluminum shade. This comparison of the ability of the two materials to reduce the radiant heat load is the effectiveness of the material—the E-value.

The standard, aluminum, has an E-value of 1.00. A material with an E-value greater than 1.00 is more effective than aluminum in reducing the radiant heat load. A material with a lower value is less effective.

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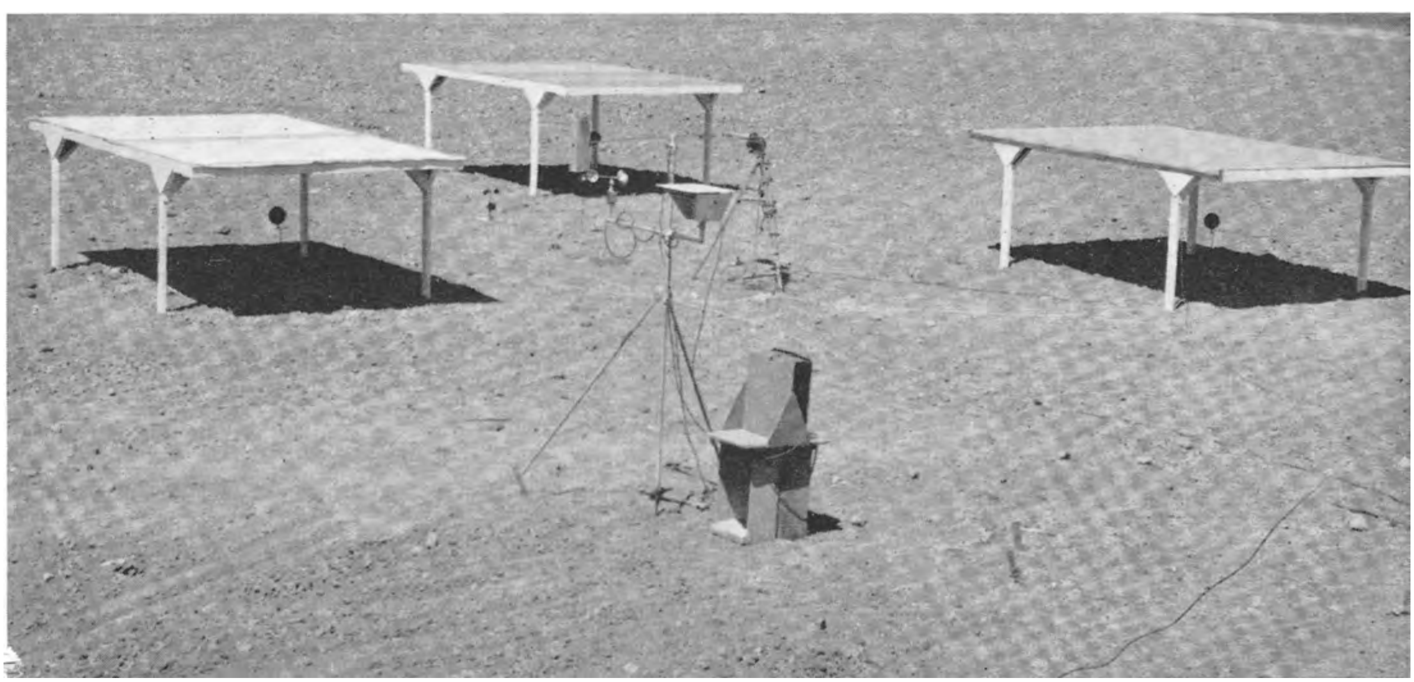
Comparative tests of radiant heat load under four different shade materials covering 8′ × 12′ × 4′ high shade frames. Radiant heat load indicated by black globe thermometers under shades at center of shadow.



SHADES

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The E-values can be used to compare radiant heat loads under shades made of various materials. On a typical, clear, California summer day the radiant heat load from the sun will be about 270 Btu/hr per square foot of animal surface. An aluminum shade will lower this about 100 Btu/hr. Using these values, the radiant heat load under any of the materials can be approximated by multiplying its E-value by 100 and subtracting this from 270. For instance, under a hay shade—E-value 1.203—the radiant heat load during the middle of the day will be about 150 Btu/hr per square foot; under a shade of black polyethylene film—E-value 0.868—the radiant heat load will be about 183. An increase of 0.01 in the E-value of one material over another means a reduction of about 1 Btu/hr per square foot in heat load.

The effectiveness values do not take into consideration either the cost or expected life of the material, which are important to any over-all evaluation. Nor is it known whether animals will grow or produce differently under one shade or the other; the effect of a unit radiant heat load would vary with air temperature and probably with age, breed, and level of feeding. Furthermore, shade design—size, shape, height, orientation—also will influence the heat load. However, the E-values do provide a good index for weighing the relative merits of materials for shades.

View under a test frame showing black globe thermometer used to measure radiant heat load and hemispherical radiometer to measure radiation received by underside of test material.

Use of the E-values of shade producing materials is not restricted to livestock shades but is equally applicable in evaluating materials for any open-type structure.

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Shade Materials Listed in Descending Order of Effectiveness, as Compared with New Corrugated Aluminum

Material	Treatment	Effectiveness
1. Hay	6″ thick	1.203
2. Aluminum	Top white, bottom black	1.103
3. Aluminum	Top natural, bottom black	1.090
4. Combination	⅛″ Masonite, alum. foil coated top	1.068
5. Galv. Steel	Top white, bottom black	1.066
6. Combination	⅛″ Masonite, 2″ air space, galv. steel top	1.064
7. Louvres, wood	Unpainted	1.060
8. Poly-foil	1 mil alum. on 4 mil polyethylene	1.059
9. Galv. Steel	Top white, bottom natural	1.053
10. Aluminum	Top white, bottom natural	1.049
11. Neoprene nylon[1]	Top aluminum, bottom black	1.048
12. Galv. Steel	½″ insulation board underneath	1.046
13. Aluminum	½″ insulation board underneath	1.044
14. Louvres, wood	Top unpainted, bottom black	1.042
15. Aluminum	"Diamond Rib" (Kaiser)	1.038
16. Neoprene nylon[2]	White both sides, new	1.037
17. Polyethylene, 8 mil film	Black, double layer, 2″ spacing	1.036
18. Plywood, ⅜″ thick	Top white, bottom unpainted	1.031
19. Plywood, ⅜″ thick	Unpainted	1.030
20. Plywood, ¼″ thick	Unpainted	1.030
21. Polyethylene, laminated	Top white, bottom black	1.028
22. Neoprene nylon[2]	Top aluminum, bottom black	1.022
23. Neoprene nylon[2]	Yellow under, aluminum upper, new	1.016
24. Neoprene nylon[2]	White both sides, used	1.014
25. Neoprene nylon[2]	Aluminum under, yellow upper, new	1.006
26. Aluminum	Standard	1.000
27. Aluminum	One year old, unpainted	0.994
28. Galv. Steel, new	Unpainted	0.992
29. Galv. Steel	One year old, unpainted	0.985
30. Neoprene nylon[2]	Yellow under, aluminum upper, used	0.977
31. Louvres, wood	Black top, black bottom	0.970
32. Aluminum	Ten years old, unpainted	0.969
33. Asbestos Board	⅛″ thick, natural color	0.956
34. Building Paper	Aluminum coated	0.950
35. Hardboard	⅛″ thick, plain (Masonite)	0.942
36. Neoprene nylon	Thin, black	0.940
37. Neoprene nylon	Thick, black	0.933
38. Snow Fence, 2″ × 2″	Double layer, no openings	0.933
39. Saran Shade Cloth	(92% solid)	0.926
40. Shade Fence, 2″ × ¾″[3]	N & S, white top	0.901
41. Shade Fence, 2″ × ¾″	E & W, unpainted	0.894
42. Saran Pool Cover Cloth	———	0.889
43. Neoprene nylon[3]	Green both sides, new	0.880
44. Polyethylene 8 mil film	Black	0.868
45. Saran Shade Cloth	(90% solid)	0.839
46. Shade Fence, 2″ × ¾″	N & S, unpainted	0.829
47. Snow Fence, 2″ × 2″	Double layer, crisscrossed	0.823
48. Polyethylene 8 mil film	Translucent	0.774
49. Polyethylene 4 mil film	Translucent	0.677
50. Snow Fence, 2″ × 2″	N & S, unpainted	0.589

[1] Lightweight (10 oz./sq. yd.) neoprene-coated nylon.
[2] Heavyweight (16 oz./sq. yd.) neoprene-coated nylon.
[3] 2″ × ¾″ indicates 2″ lath, ¾″ spacing; N & S indicates length of slats North and South.