SOLAR SHIELDING
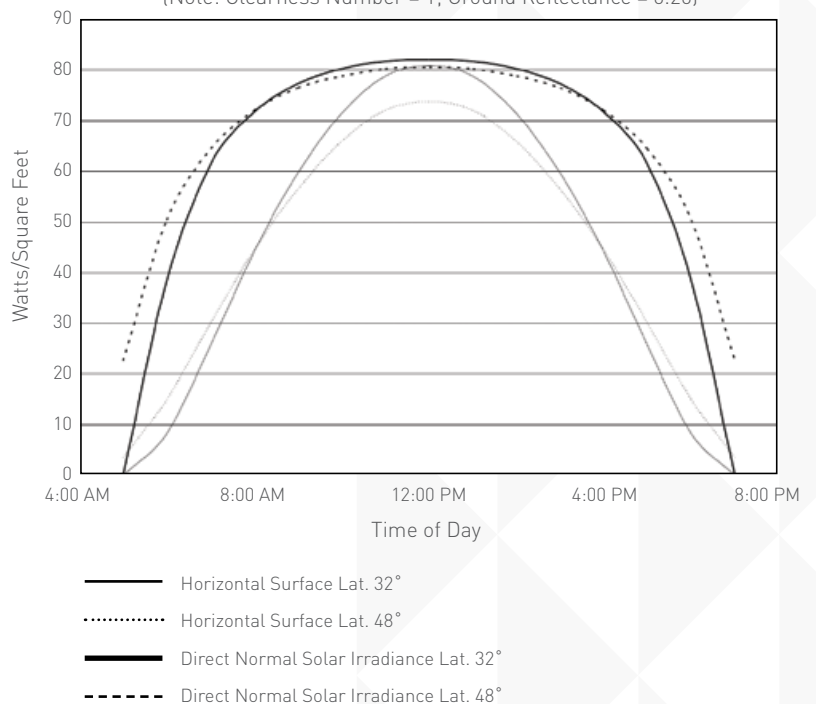## REDUCING HEAT LOAD TO PROTECT ENCLOSURE COMPONENTS

The temperature rise inside an enclosure above outdoor ambient is caused by internal equipment heat dissipation and solar energy absorption. Some common thermal management solutions for enclosures include air conditioners, heat exchangers, ventilation and color when evaluating solar loading. This article is written to present the beneficial temperature effects of shading the enclosure's surface by shielding the direct and reflective radiation from the sun.

BACKGROUND:
CLIMATE AND SOLAR LOADING

The amount of solar radiation striking a perpendicular surface located beyond the earth's atmosphere at the mean earth-sun distance is called the **solar constant Esc** $\cong$ 1366 watts/m2 (127 W/ft2; 433 BTU/(h • ft2). Absorption by water vapor, dust and ozone, while passing through the earth's atmosphere will reduce this value. The typical extreme value of a horizontal surface over most of the United States is 1044 W/m2 (97 W/ft2). In the upper altitudes with clear dry climates, as in the southwestern regions of the United States, extreme horizontal surface values of 111 W/ft2 are possible. An examination of Weather Bureau data indicates that maximum ambient air temperatures of 104°F (40°C) are only exceeded in Arizona, Nevada and California (ref. IEEE C37.26-1986; IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear).

The graph below represents average hourly solar loading for June. Peak intensities will be greater; this however, provides a good illustration of the variation of solar loading attributed latitude. The latitudes selected, 32°- 48°, represent the approximate northern and southern borders of the United States.

June Time of Day Solar Irradiance and Solar Heat Gain Factors (ASHRAE) for Latitudes 32° North and 48° North
(Note: Clearness Number = 1; Ground Reflectance = 0.20)

——— Horizontal Surface Lat. 32°

·············· Horizontal Surface Lat. 48°

━━━ Direct Normal Solar Irradiance Lat. 32°

------ Direct Normal Solar Irradiance Lat. 48°
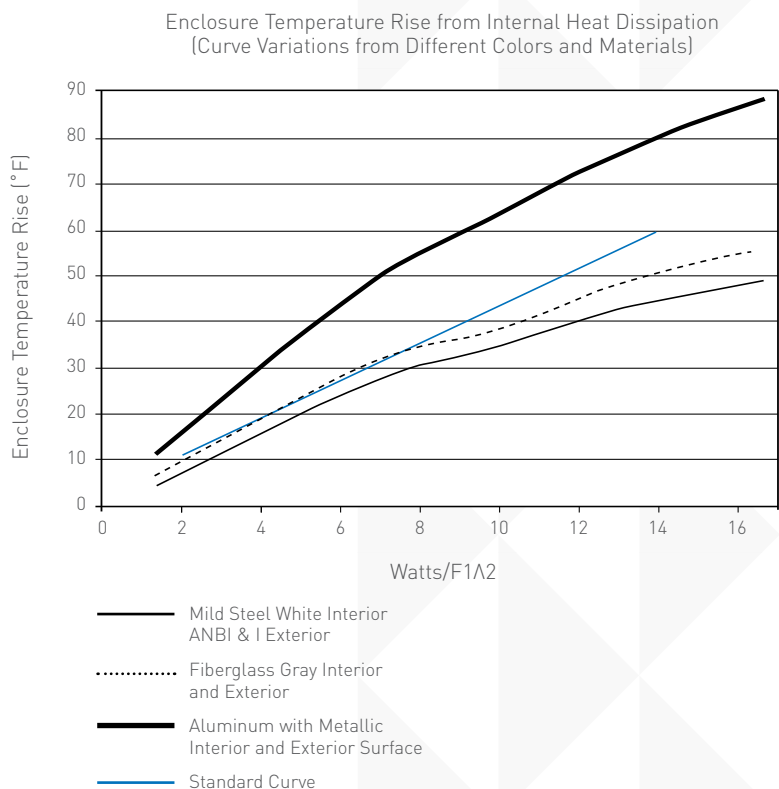
BACKGROUND:
SOLAR ABSORPTION COLOR

The percent of solar energy absorbed by an enclosure is dependent on surface color, finish and texture. Low temperature radiation (larger wavelengths) presents a different set of values for surface color. Low temperature values affect an enclosure surface's ability to absorb internal heat loads and dissipate radiant heat to the sky and surrounding objects.

When selecting an absorption value based upon the surface color of an enclosure, the value should be inflated. Absorption values of the finish will increase with age. Mounting location can magnify the solar gain by as much as 40% when located around reflective ground surfaces and buildings. Location may also block some of the connective cooling effects.

Surface	Solar Radiation (a_2) Absorption	Low Temperature Radiation 25˚C (Є) Emission & Absorption
Polished Aluminum	.15	.06
White	.14	.97
Yellow	.30	.95
Cream	.25	.95
Light Gray, Green Blue	.50	.87
Med. Gray, Green Blue	.75	.95
Dark Gray, Green Blue	.95	.95
Black	.97	.96

BACKGROUND:
SURFACE COLOR AFFECTS THE LOW TEMPERATURE RADIATION

Surface finish and color relates to the percentage of radiation emission and absorption to surrounding objects. The graph below illustrates the effects of surface color on low temperature radiation. From a relatively low temperature source (resistive heater), the metallic surface absorbs less of the internal dissipated heat causing an increased temperature rise. An enclosure's ability to dissipate internal heat in W/°F generally is less for shiny metallic surfaces compared to other finishes. An enclosure made of mild steel with white interior absorbs and dissipates heat similar to a fiberglass enclosure with a gray interior.

Enclosure Temperature Rise from Internal Heat Dissipation
(Curve Variations from Different Colors and Materials)

Mild Steel White Interior ANBI & I Exterior

Fiberglass Gray Interior and Exterior

Aluminum with Metallic Interior and Exterior Surface

Standard Curve

SOLAR SHIELDING TEST

Hoffman has conducted a series of tests to evaluate the thermal benefits of shielding enclosures exposed to direct sunlight. The objective was to capture and compare the internal enclosure temperatures of non-vented NEMA Type 4 enclosures. Three enclosures were configured. One without shielding and two enclosures with different amounts of shielding. The first experiment included no internal heat source; the temperature rise is solely attributed to solar load. The second experiment added 100-watt internal heaters. The purpose of adding heaters was to identify the enclosure's ability to dissipate heat with the added shielding.

The results of a typical peak day are illustrated in the graph on the right. The curves show the internal time-based temperatures within each of the different enclosures. The shielding provides definite temperature reduction. In both experiments, during peak daytime loading, the enclosure with only a top shield provided about a 5°F temperature reduction, while the top and side shielded enclosure provided a 10°F temperature reduction. This equates to a relative 25% and 50% respective reduction. This result was also consistent in the test run with internal heaters.

Illustration of the test set-up. The enclosures used were Hoffman COMLINE® model E-CL605020 (600mm H X 500mm W x 200mm D). They are RAL 7035 (Textured Light Gray) in finish and color. The top solar shield is model E-SSH5020.

COMLINE (E-CL605020) Enclosure Internal Temperature Comparison with Solar Shield (E-SSH5020)
Internal Temperature Rise Above Outside Ambient is Caused by Solar Radiation
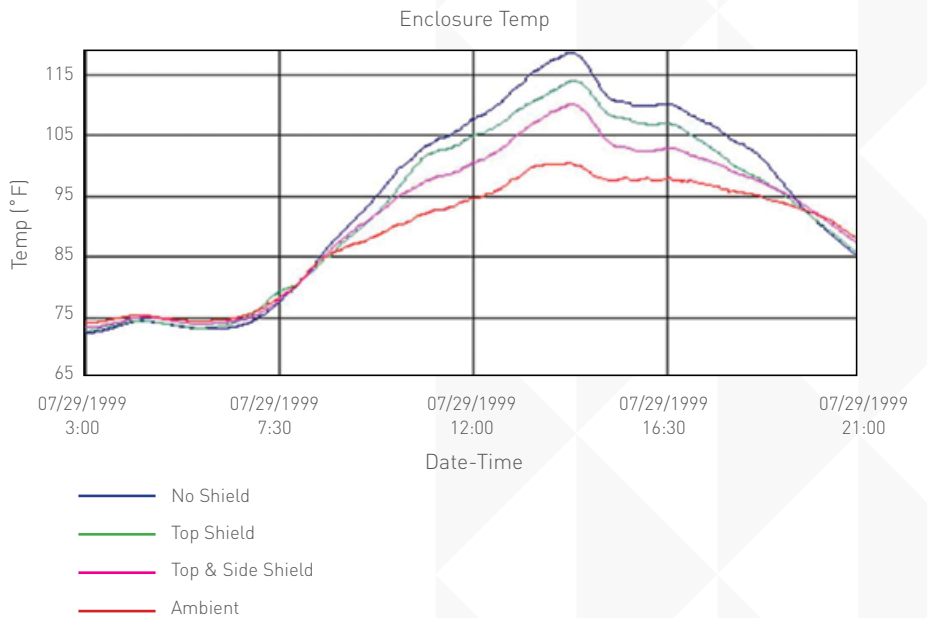
Enclosure Temp

— No Shield
— Top Shield
— Top & Side Shield
— Ambient

CONCLUSION

The graph on the right approximates an enclosure's temperature rise due to solar loading. The temperature rise is based on absorption color evaluated with worst case parameters. The dashed lines represent a fully shielded enclosure.

The worst case assumptions when evaluating solar loading of an enclosure are that three sides of an enclosure are illuminated, there is no wind and the sky temperature is equal to the ambient.

- Total surface area of the enclosure must be calculated
- Color selected
- Internal dissipated heat known
- Maximum allowable internal temperature must be determined

The evaluations shown in this text are approximated curves to assist the user in identifying load values and temperature rises. Actual internal temperatures may vary depending on panel layout. For active cooling systems, it is recommended to provide a safety margin by selecting a system with 25% additional capacity.

There are definite cooling benefits to solar shielding enclosures, as illustrated in the graphical data. The shielding application may even be incorporated with active cooling systems to reduce the required size or loading of an air conditioner or heat exchanger. Certainly a benefit of this passive cooling system is the avoidance of untimely maintenance. Passive cooling with a solar shield is a reliable alternative. Visit hoffmanonline.com for complete technical and product information.

Internal Temperature Rise in Enclosure from Solar Load Based versus Surface Color (dashed lines illustrate shielded enclosure)

Legend:
- Solar Gain Enclosure Qint = 0 Watts
- Solar Gain Enclosure Qint = 8 Watts
- Enclosure with Solar Shield Qint = 0 Watts
- Enclosure with Solar Shield Qint = 8 Watts/SF

![PENTAIR]