Effect of Internal Shades on Cooling Loads

This HAP e-Help will discuss the effect of internal “shading” on the solar heat component of the cooling load. There are various types of internal shading devices that are modeled in the HAP program. These include drapes, shades, and venetian blinds. For this discussion, we will use closed-weave drapes to demonstrate the effect on the solar heat load.

Interior window shading devices will affect the conduction and convection heat flow along with the solar radiation that can enter the building. When interior shades are added to a window, the final overall window U-value along with the overall glass shade coefficient change, and therefore the transmission and solar loads through the entire window assembly are affected.

Overall Shade Coefficient is particularly important since it describes how solar energy is transmitted through the entire window assembly. Solar energy is one of the major components in window assembly heat gain. The overall shade coefficient is the Solar Heat Gain Coefficient (SHGC) of the window assembly divided by the Solar Heat Gain Coefficient through a single pane of reference glass. The reference glass used is a single pane of 1/8" clear glass. SHGC is the ratio of solar heat gain inside the window to solar heat flux striking the outside of the window. The overall shade coefficient accounts for the difference between the combined properties of the window glass, framing, and any interior shading device versus the properties of clear reference glass containing no shading.

HAP will automatically calculate the overall shade coefficient using ASHRAE and NFRC (National Fenestration Rating Council) estimation procedures when using the “Detailed Input” approach in the Window Properties as shown in Figure 1. The calculation considers solar energy transmission through the glass portion of the window, solar heat absorbed and transmitted through the window frame, the heat absorbed by the glazing in the window assembly, and the effects of the internal shading device.

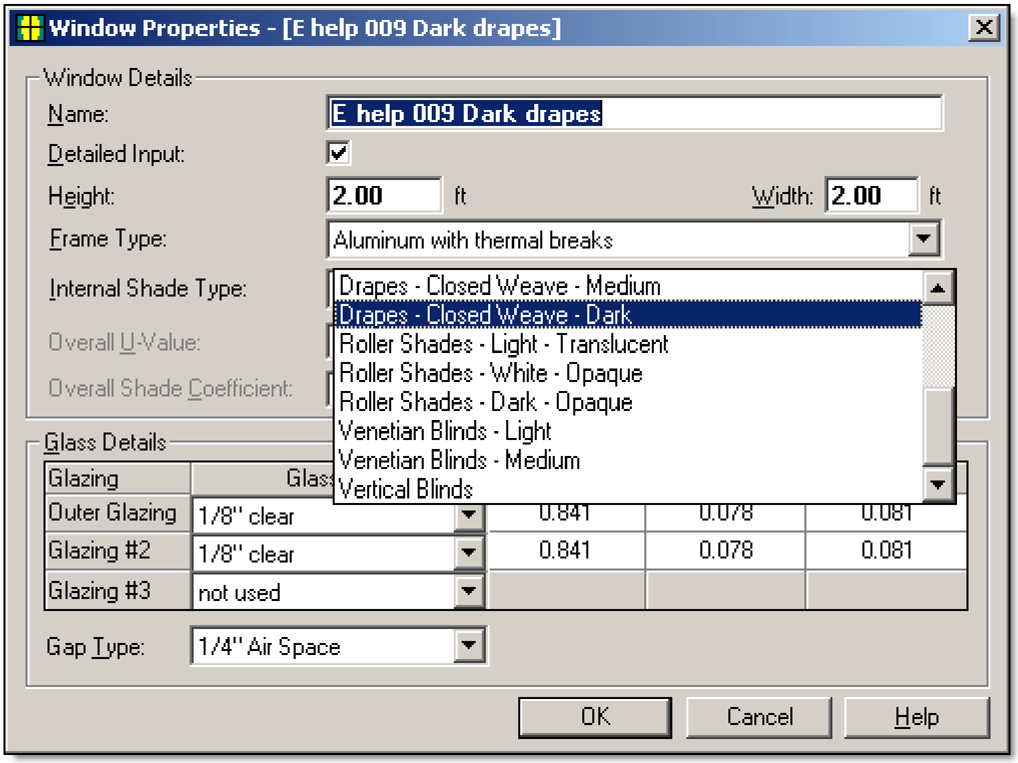

Figure 1 – Window Properties Detailed Input Screen Showing Internal Shade Choices

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We will now examine an interesting phenomenon. ***Adding certain internal shading devices can increase the peak solar load of the window versus the same window without shades!*** This larger solar load component could possibly result in a larger overall *peak* load for the zone containing the window with the shades. A HAP model was created to demonstrate this. For this model, three 2 ft x 2 ft window assemblies were created: one with no shades, one with light shades, and one with dark shades. Then, each window was placed in a space, and each space was made a zone in a VAV air system. Other loads elements such as wall areas, people, and lights were not incorporated in the model in order to observe the effect of internal shades on just the solar component. In this model, an east exposure, a lightweight building structure, and a sunny month (July) were selected. Load calculations were run and the Hourly Zone Design Day Loads reports were requested.

HAP can generate a separate graph for each zone. However, in order to see the dynamic “shift” in magnitude due to time of the hourly solar values, all three zone profiles were plotted on one graph as shown in Figure 2. Notice the “Dark Shade” results in a higher peak load and shifts the peak to an earlier time (from 9 am to 8 am) versus the window with “No Shades”. This is due to the heat absorbing characteristics of the dark shades coupled with the light mass of the shades. Notice the light shade has a combined effect of both reducing the peak solar load and shifting the peak load one hour earlier. The area under the light shade curve is less than both the no shade and dark shade cases, indicating the light shade is the best option from a thermal performance standpoint.

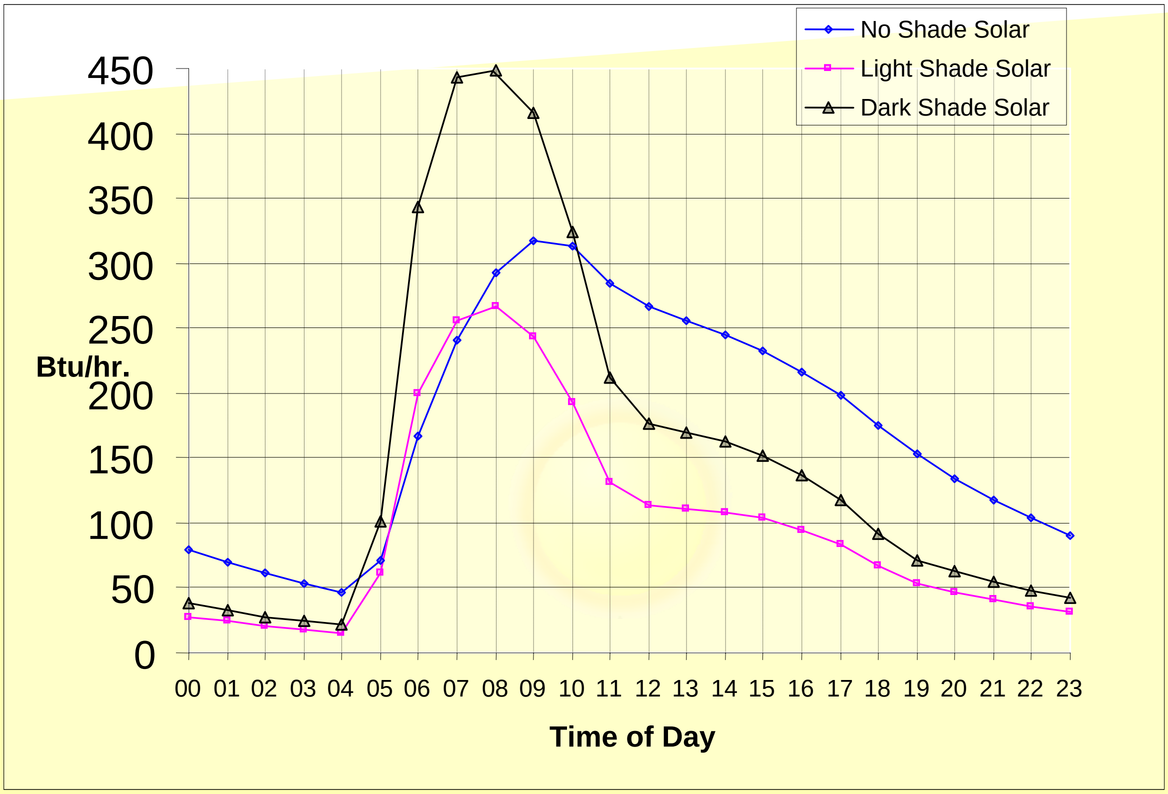

Figure 2 – Hourly Air System Design Load: July, East Exposure

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The conversion of the solar heat gain to an actual load happens much faster when shades are used. This is because the internal shade has a very low thermal capacitance (specific heat x mass), allowing the solar heat absorbed by the shade to be converted into an actual load much sooner. (For more information on how heat gains are converted into cooling loads, see HAP e-Help 004, Transfer Function Methodology). Without internal shades, the conversion of solar heat gain to zone cooling load is slower because the building thermal capacitance is greater than that of the shade device. As a result, solar heat reaches the floor and walls directly and is absorbed by the building mass. Heat is stored longer because the thermal capacitance of the structure is much greater than the lightweight internal shade device. This results in the changes to the shape of the solar load profiles in Figure 2. Without shades, the profile for the same window has a lower, wider peak than with shades.

As a side note, the Btu/hr values shown in Figure 2 also contain a transmission heat gain component for the window. So, these curves do not represent purely solar heat gain. The transmission is reduced by the use of shades since these devices reduce the overall U value of the window assembly.

Conclusion:

The hourly peak solar load component for a window assembly is affected not only by the use of shades but also by the heat absorbing characteristics of the shade itself. When compared to light colored shades or no shades, dark colored shades absorb more solar heat and release it sooner where it becomes an immediate cooling load in the space. Lighter colored shades reflect a portion of the solar gain back out of the window and a smaller peak load results. Regardless of whether light or dark internal shades are used, the total solar heat load through the window assembly over a 24 hour period is less for windows with any type of shade than without. This can be seen by comparing the resulting area under each curve.