TECH TIP # 18

HEATING, AIRCONDITIONING & REFRIGERATION DISTRIBUTORS INTERNATIONAL

One of a series of dealer contractor technical advisories prepared by HARDI wholesalers as a customer service.

LARGE ROOF OVERHANG -- A NEGLECTED ENERGY SAVER!

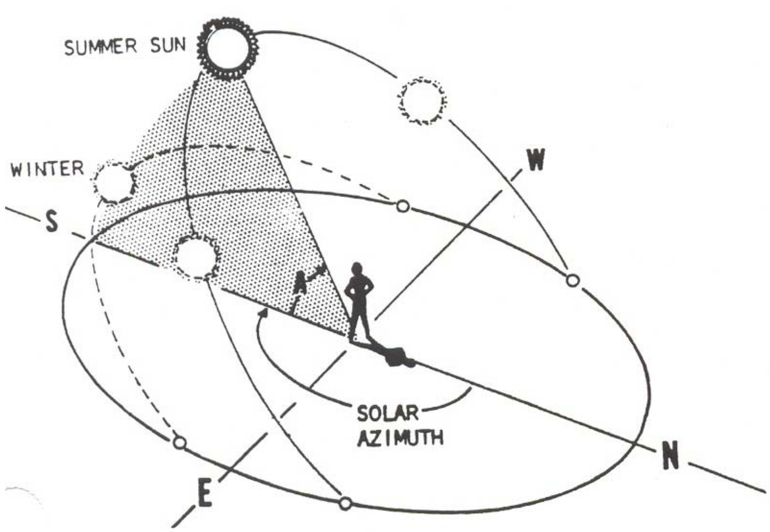
Of direct interest to the air conditioning contractor is the fact that a large roof overhang can shade glass from the direct rays of the sun and thus reduce the house cooling load.

The total heat gain through glass is a combination of direct and diffuse solar radiation plus conduction transfer as a result of indoor outdoor air temperature differences. At design conditions, direct solar radiation constitutes the major source of the total heat gain due to glass.

At 3:00 p.m. in mid summer, the total heat gain of single glass is typically 93 Btuh/sq ft. Of that amount 55 Btuh/sq ft heat gain is due to direct solar radiation, 26 Btuh/sq ft due to diffuse radiation and 12 Btuh/ sq ft due to air temperature difference across the glass. Now if at 3:00 p.m. the glass was entirely shaded, the 55 Btuh sq ft direct gain component would not occur. Shading in this case would effect a 60 percent reduction in heat gain. To be sure, not all reductions are that drastic.

The length of shadow cast on a wall because of a roof projection depends on 1) the hour of the day; 2) time of the year; and 3) the orientation of the wall with respect to true north.

From the point of view of an observer on earth, the sun rises in the east, arches across the southern sky and sets in the west. And in summer, the sun is higher in the sky than in the winter (see Fig. 1).



1. Sun's position affects the shadow cast on a wall or window. The position of the sun is defined by the altitude angle A and solar azimuth -- the angle between an imaginary vertical plane drawn through the sun perpendicular to the horizon (shaded area) and the north direction.

(continued)

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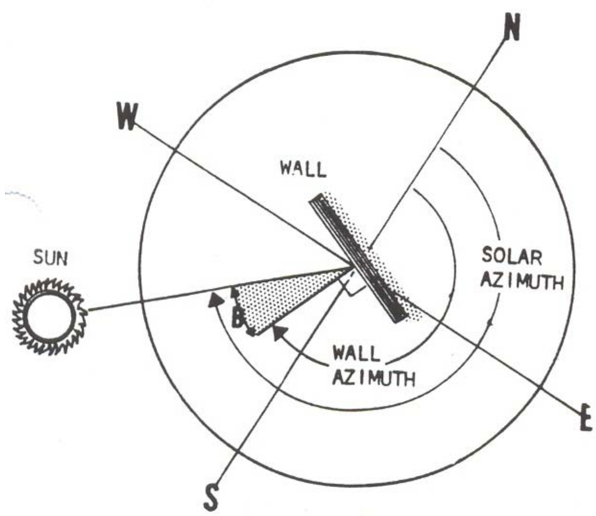
The sun's position at any time of the year can be described using two coordinates (angles). The solar altitude angle (A) is used to describe the height of the sun above the horizon. It's officially defined as the angle between an imaginary vertical plane drawn through the sun and intersecting a horizontal plane drawn through the observer's feet. The maximum noon time solar altitude angle occurs on June 21st and the minimum on December 21st of each year.

The solar azimuth angle is the angle between the compass north direction and an imaginary vertical plane drawn through the sun. A solar azimuth angle of 180 degrees, for example, indicates that the sun is due south. Value for both solar altitude and solar azimuth are available in many texts, including Hydrographic Bulletin 214 from the U.S. Government Printing Office.

A third angle is sometimes used to relate the wall orientation to the sun's position. The wall azimuth angle is defined as the angle between the north direction and a line perpendicular to the face of the wall in question (see Fig. 2). An east facing wall, therefore, has a wall azimuth angle of 90 degrees and a south facing wall 180 degrees.

The difference between the wall azimuth and the solar azimuth angles is logically referred to as the wall solar azimuth (angle B in Fig. 2). This is an important angle, as it is an integral part of the shade line formula.



2. WALL SOLAR azimuth angle B (shaded area) is the difference between the solar azimuth angle and the wall azimuth -- angle between north direction and line perpendicular to wall.

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The basic relationship to determine the length of shadow cast by a roof overhang in any latitude and for any time of the year is as follows:

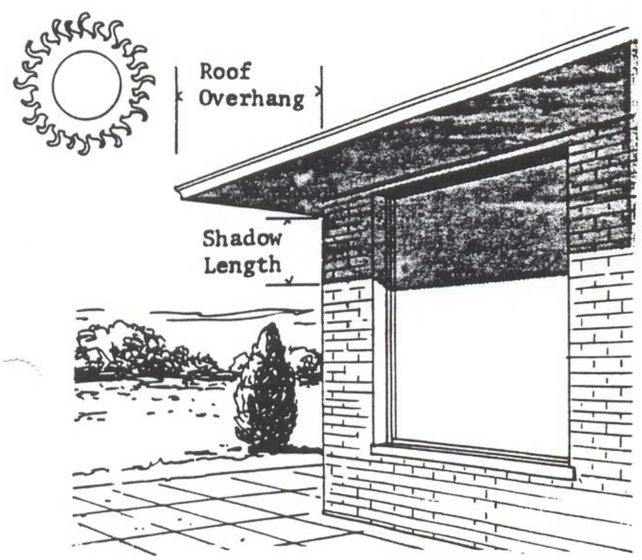
Shadow length (ft) = roof overhang (ft) x (tan A/cos B)

Where A is the solar altitude angle for the specific day and hour of the year, and B is the wall-solar azimuth angle, and tan and cos are natural trigonometric functions readily obtained from tables are a scientific calculator.

At 40 degree north latitude, on August 24th at 12:00 noon, the solar altitude angle is 61 degrees. The solar azimuth is 180 degrees. Find the length of shadow cast on a south facing wall shielded by a 2 foot roof projection.

A south facing wall has a wall azimuth of 180 degrees, therefore, the wall-solar azimuth angle (B) is 180 minus 180 or 0 degrees. Using the basic formula, and referring to tables for values of tangent and cosine of the angles:

Shadow length = 2 x (tan 61/cos 0)
= 2 x (1.8/1.0)
= 3.6 ft.



Thus, the shadow cast by a 2 ft. overhang is 3.6 feet down from the top of the wall for a south facing wall at 12:00 noon. If the wall was facing southeast, the wall azimuth angle would be 135 degrees and the wall-solar azimuth would be 180 - 135 or 45 degrees.

The shadow cast on the southeast wall for the same time would then be:

Shadow length = 2 x (tan 61/cos 45)
= 2 x (1.8/.707)
= 5.1 ft.

Table 1 - SHADE LINE factors for 40 degrees north latitude (spring and summer months). Multiply appropriate factors times overhang to find shadow length. See illustration above.

Time of day	Wall facing East	Wall facing South	Wall facing West
8 am	0.53	2.33	Shade
9	0.89	1.85	Shade
10	1.54	1.73	Shade
11	3.25	1.64	Shade
12 noon	Shade	1.59	Shade
1 pm	Shade	1.64	3.24
2	Shade	1.73	1.54
3	Shade	1.85	0,89
4	Shade	2.33	0.53

At 3:00 pm on the same day, the solar altitude decreases to 41 degrees and the solar azimuth angle increases to 247 degrees. What happens to the shadow on the south walls?

For the south wall:

Shadow length = 2 x tan 41/cos (247-180)
= 2 x (0.87/0.39)
= 4.65 ft.

For the southeast wall:

Shadow length = 2 x tan 49/cos (247-135)
= 2 x (0.87/0.93)
= 1.88 ft.

Thus as experience indicates, the shadow on the south wall lengthens in the late afternoon while the shadow on the southeast wall decreases.

Using the basic formula it's possible to develop simplified charts or tables of shade factors to speed up routine design work. Simplification is readily accomplished by restricting the table to some specific latitude or time of year. It's also possible to consider mean values of solar altitude and azimuth angles that would apply to a selected period of time, say three, four or more months.

For instance: it turns out that the sun's altitude and azimuth angles are essentially the same in March and September --- April and August and May and July. Thus, mean values of solar position could be computed for the entire spring and summer months in keeping with reasonable design accuracy.

Table 1 illustrates shade factors for 40 degrees north latitude computed on this basis. These values multiplied by the roof overhang yield the average shadow length, hour by hour, applicable from April to September. Similar tables for other latitudes can be constructed.

In residential work, where hour by hour glass loads are analyzed, the design shade line factor is generally an average of five values computed over the five hours of maximum heat gain one on specific date, usually August 1.

Once the shaded glass area is determined, it is treated separately in the cooling load calculation.