# TECH TIP # 41

HEATING, AIRCONDITIONING & REFRIGERATION DISTRIBUTORS INTERNATIONAL

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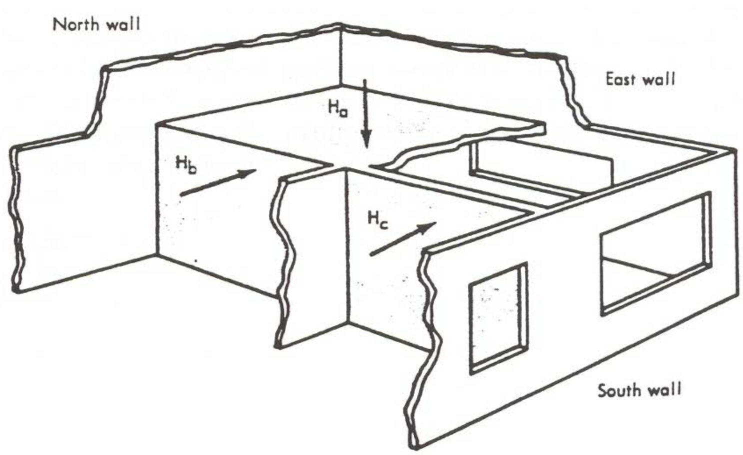
## How to Calculate Air Temperatures in Unconditioned Spaces

Frequently it may be necessary to know the air temperature of an unheated area, say of an *attic* space in a residence or of a *storage room* in an apartment. We may, for example, need to know the approximate temperature in these areas to appraise whether pipes would freeze, or perhaps to more precisely estimate heat losses through wall partitions separating conditioned rooms from these unconditioned areas. Whatever the reason, the problem of estimating air temperatures need not be a source of concern nor left to a mere guess. There is available a simple procedure to calculate air temperatures in unconditioned spaces.

### Heat Flow In Equals Heat Flow Out

Much like the old adage, *What goes up must come down* (obviously a saying predating satellites), in steady state heat flow, what heat flows *into* a room must flow *out*. If this does not occur, the space temperature would rise or fall as it would be storing or losing heat.

1 UNHEATED ROOM exists at a temperature somewhere between the outdoor temperature and that of heated rooms adjacent to it. For steady conditions, heat flow into the room from heated spaces, equals heat flowing out through room's walls exposed to the out-of-doors. Exact temperature maintained depends on the ratio of exposed wall surface to common partition area and the thermal fitness of each.




Let's consider the east room shown in Figure 1 as being an unconditioned area. Further, assume there are heated rooms above and adjacent to this room. Neglecting any heat flow into the ground (or basement) heat is flowing into this room from above, through the floor ($H_a$), and through two walls $H_b$ and $H_c$. At the same time, heat is flowing out of the room through the north ($H_n$) south ($H_s$), and east ($H_e$) walls. Equating all these terms together, we have: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**Heat flow in = Heat flow out**

$\mathbf{H_a + H_b + H_c = H_n + H_s + H_e}$

But heat flow from each of the unconditioned rooms, in turn, is equal to the appropriate U value times the area of the wall, floor, door or glass section in question, times the temperature difference across the wall. For example, the heat flow from the floor above is equal to:

$\mathbf{H_a = U_aA_a(T_i\text{-}T_u)}$

where

$H_a$ = heat flow in, from room above

$U_a$ = heat transfer coefficient for floor

$A_a$ = area of floor

$T_i$ = air temperature in conditioned space

$T_u$ = air temperature in unconditioned space

and for the south wall of the unconditioned space.

$\mathbf{H_s = U_wA_w(T_u\text{-}T_o) + U_gA_g(T_u\text{-}T_o)}$

$H_s$ = heat flow out, from south wall

$U_w$ = wall heat transfer coefficient

$A_w$ = net wall area

$U_g$ = glass heat transfer coefficient

$A_g$ = glass area

$T_u$ = air temperature of unconditioned space

$T_o$ = outdoor design temperature

Now, if we substitute all factors into our *Heat in = Heat out* equation we find that:

$$\frac{\mathbf{T_i - T_u = \text{Sum of all U x A's for Exposed Surfaces}}}{\mathbf{T_u - T_o = \text{Sum of all U x A's for Common Partitions}}}$$

All the terms in the above equation are known except $T_u$ - which is what we want to determine.

**Example Reveals Simplicity**

Let's assume some temperatures, areas and U values for the rooms shown in Figure 1 to illustrate exactly how to calculate the unconditioned room's air temperature.

First of all, let's assume $T_i$, the inside design temperature, is 75º F, and $T_o$, the outside design temperature, is 0º F. Next common partition areas are: floor area above is 360 square feet, and wall areas are 96 square feet each. Unconditioned room exposed surface areas are: north wall 120 sq. ft. south wall (net) 70 sq. ft., south glass 50 sq. ft., east wall (net) 132 sq. ft., east glass 60 sq. ft. U value for common partitions is 0.3 Btuh/sq. ft. degree F. U value for exposed walls is 0.1 Btuh/sq. ft. degree F. U value for glass is 0.6 Btuh/sq. ft. degree F.

Substituting in our equation we have:

$$\frac{\mathbf{75 - T_u}}{\mathbf{T_u - 0}} = \frac{\mathbf{0.1(120 + 70 + 132) + 0.6(50 + 60)}}{\mathbf{0.3(360 + 96 + 96)}}$$

Solving, we find that $T_u$ = 48º F

Note: the air temperature in the unconditioned space will be the mean between the inside and outside air temperatures only when the common partitions and exposed surfaces of the unconditioned space are nearly the same in area and have nearly similar U values.)

**Procedure Has Limitations**

For unheated spaces containing exceptionally large glass areas with multiple exposures, and also spaces which might experience exceptionally large in-leakage of outdoor air, it is best to assume that the unconditioned space temperature will approximate the outdoor temperature.