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DISCUSSION

C. G. Cash[1] *(written discussion)*—Have you done any work on the development of condensation at fasteners?

D. M. Burch, P. J. Shoback, and K. Cavanaugh (authors' closure)—We have not done any work on an analysis of condensation at fasteners.

R. J. Moore[2] *(written discussion)*—This paper modeled by computer the metal deck and metal-capped fastener having thermal resistance in the lateral direction but not in the longitudinal direction. The authors used an inside temperature of 21°C (70°F), and an outside temperature of −18°C (0°F). Their model showed all fasteners penetrating through the decking substrate.

No assumption was made for the interior relative humidity. Assuming a normal relative humidity of between 30 and 40%, the dew point of that mix would be on an order of magnitude of 1 to 6.6°C (34 to 44°F). Any fastener that comes in contact with that mix will condense at 6.6°C (44°F) or colder. Expressed another way, any outside temperature colder than 6.6°C (44°F) will cause condensation on these fasteners. With a fastener approximately every 0.186 m^2 (2 ft^2), it is reasonable to assume that liquid water will appear within that insulation assembly every 0.186 m^2 (2 ft^2) throughout the entire system. The double layer of insulation is a major assistance; however, the double layer must be of adequate thickness and thermal resistance to prevent the head of that fastener reaching 9.4°C (15°F).

I asked a question from the floor during the symposium about the effect on the authors' computer numbers if 3 to 5% water was present, and the speaker said that obviously the numbers would be changed. It would be interesting to see a computer run with the additional element of liquid water present every 0.186 m^2 (2 ft^2) throughout the assembly.

Back in the late 1950s and early 1960s, Factory Mutual created a monstrous problem within the roofing industry by requiring strip mopping on the flanges of steel decks to make insulation adhere. The method failed. Cold adhesives for attaching insulation also failed. Now, beginning in approximately 1983, there is a major movement throughout the country to fasten all insulation to the deck with deck-piercing fasteners. I predict that we are generating another problem: that is, the presence of condensation on these fasteners when they come in contact with the interior mix of temperature and humidity. The situation is compounded if the hung ceiling area is used as a return air plenum. In that case, all the moist air within the entire building is passed underneath these fasteners, which have created real holes in the metal decking to allow the movement of vapor into the insulation above and membrane assemblies.

The industry is making great progress teaching the use of *K*, *R*, and *U* values of thermal insulation. I feel the industry must now move quickly to teach all those involved how to use a psychrometric chart, plot dew points, and calculate interior assembly temperatures.

It is as dangerous for a roof system to live on top of a pond as to live under a pond.

D. M. Burch, P. J. Shoback, and K. Cavanaugh (authors' closure)—The finite-difference model used in the analysis of this paper may be used to predict the temperature of a fastener where it penetrates a roof deck. If the fastener temperature is below the dew-point temperature of air in contact with it, then condensation will occur at this location.

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The authors concur with the comments of the questioner that the penetrations of fasteners in a roof deck may permit moisture to enter the roof system. However, an analysis of the effect of this moisture on the thermal performance of the roof system would require a considerably more complex model than the one given in this paper.