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A SOURCE BOOK ON GOOD PRACTICES FOR DESIGN, INSTALLATION, AND MAINTENANCE OF INSULATED ROOF SYSTEMS

IEA ANNEX 19
LOW-SLOPE ROOF SYSTEMS

INTRODUCTION

The Buildings and Community Systems Executive Working Group of the International Energy Agency (IEA) formed an annex (Annex 19) to address energy issues related to low-slope roof systems. The first task undertaken by the annex has been development of a sourcebook on good practices for design, installation, and maintenance of insulated roof systems. The intent of the sourcebook is to provide a discussion of both real and perceived correlations between roof systems and to present information on recent roofing issues that have insulation implications.

ANNEX UPDATE

Annex members have identified and reviewed a list of 25 potential correlations between roof problems and insulation. The review process has reduced the list to 11 items, listed in Table 1. The Annex will meet in May 1992 to discuss changes made in the third draft of the document and to begin the editing process. This most recent draft contains an update of several issues that are changing rapidly; for example, CFCs in foams, wind uplift, and treatment of wet insulation. Material on the latter issue is included in this report.

MOISTURE DISCUSSION

Preventing water from penetrating into roofs and subsequently damaging interior spaces of buildings has always been fundamental to good roof design and maintenance. There are additional issues for well-insulated roofs. Insulation increases the investment in a roof, and if the insulation is wet, it is not providing the design thermal resistance, nor is it providing the design operating cost savings. Further, when reroofing becomes necessary, the decision of whether to recover or discard wetted insulation has significant cost considerations, it not being uncommon for insulation to account for half the capital investment of a well-insulated roof. Leak source identification is also more difficult in insulated systems. Water can move laterally away from a source in the insulation, and some insulations, particularly fibrous insulations, can absorb large quantities of water. Thus, large areas of a roof can be wet before leakage to interior spaces is observed. These concerns accent the need for strong leak prevention measures. This includes proper flashing details, positive slope, and good drainage, as well as strong routine maintenance practices.

Membrane leaks and water trapped during construction are usually more important than condensation of water vapor from the building interior (Tobiasson, 1986). There are situations, however, when roof wetting from below is a factor. For example, buildings with high interior humidity and buildings with cold deck roof systems. In these instances, extra protection, usually a continuous vapor retarder, may be desirable. It is good practice to consciously raise the issue of whether to use a vapor retarder in every roof design. An important factor to consider is that a roof experiences both diurnal and seasonal dynamic effects. Both steady state (ASHRAE, 1991) and transient (Pedersen, 1990) calculations show that moisture is driven into a roof from below during cold weather (wetting season) and out of the roof during warm weather (drying season), as illustrated in Fig. 1. Whether or not moisture accumulates in the roof depends upon the length of the wetting season compared to the drying season and upon the strengths of the relative driving forces. For sites with long drying seasons, vapor retarders are most likely not needed.

If a continuous vapor retarder is used, there is another consideration. Water trapped during construction or water that enters the roof through a leak will be between two impermeable surfaces; the membrane and the vapor retarder, with no opportunity to escape. Roof vents, which are used to reduce high water vapor pressure during hot days, have been shown to be ineffective for removal of significant quantities of moisture (Tobiasson, 1983). A novel vapor retarder, the "hygrodiode", that allows a wet roof to dry downward while still providing protection during the wetting season is available (Korsgaard, 1985). The hygrodiode is illustrated in Fig. 2. The product is a layered composite system consisting of a porous synthetic fabric with wide strips of impermeable plastic film alternating with narrow open areas on both sides. The plastic strips are staggered so that an open area on one side is always opposite a plastic strip on the other. Thus, diffusion of water across the system is kept small because the path length is long. On the other hand, roof water will condense on an open area on the top side and readily wick along the synthetic fabric to the open area on the bottom side where it evaporates to the room interior.

The ability of a roof to dry downward is an important factor in reroofing decisions. Tear-off of wet insulation may not be necessary if moisture can be vented to the interior in a timely fashion after a new membrane seals the system from the top. This issue is particularly important in nations that saw big increases in the use of roof insulation in the 1970s (Sheahan, 1989). Roof coverings for these systems are reaching their useful lifetimes in increasing numbers, and there are strong cost and environmental incentives to keep the original insulation in place. These incentives are balanced by concerns that moisture in existing insulation may damage a new roof system.

When should recover of existing wetted insulation be considered? A key factor is timing; whether the insulation has time to dry before the moisture can damage the new system. The Single Ply Roofing Institute in the USA is currently developing a procedure to help answer this question in special cases (SPRI, 1992). As an example, in Fig. 3, the old system is fibrous insulation over a metal deck. The fibrous insulation has known water vapor permeability and known saturation water content, and the deck has a known "effective" water vapor permeability. The new system has sufficient new insulation so that the temperature at the old membrane surface is nearly the same as the interior temperature. In this case, the water vapor pressure difference and the rate at which water is transported from the roof to the room is readily calculated from the saturation vapor pressure over the deck and the room relative humidity, both at room temperature. Finally, also knowing the amount of water initially present in the old roof allows calculation of the drying time. One must then independently assess whether this time is short enough to avoid damage to the new system. For more complex roof systems, and for situations when real weather conditions must be accounted for, the calculations are beyond the scope of this technique. More comprehensive models are currently under development (Pedersen, 1991).

Table 1. Roof problems peculiar to or made worse by insulation.

Membrane Splitting Over Insulation
Membrane Blistering
Construction Water and Condensation
Diurnal Hygrothermal Cycling
Localized Ponding and Freezing
Corrosion of Metal
Physical Deterioration of Insulation
Thermal Bridging
Thermal Drift
Flashing Pull-Away
Roof Leak Detection

ASHRAE Handbook of Fundamentals, American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA, USA. 1989.

Korsgaard, V., "HygroDiode Membrane: A New Vapor Retarder," *Proceedings of the ASHRAE/DOE/BTECC Conference on Thermal Performance of One Exterior Envelope of Buildings III*, December 2-5, 1985. Available from ASHRAE, Atlanta, GA, USA.

Pedersen, C. R., "Combined Heat and Moisture Transfer in Building Constructions," Ph.D. Thesis, Thermal Insulation Laboratory, Technical University of Denmark, February 1990.

Pedersen, C. R., G. E. Courville, "A Computer Analysis of the Annual Thermal Performance of a Roof System With Slightly Wet Fibrous Glass Insulation Under Transient Conditions," *J. Thermal Insulations*, Vol. 15, October 1991, Technomic Publishing Co., Inc., Lancaster, PA, USA.

Sheahan, J. P., "Method for Determining Suitability of Roofing Over Roof Assemblies in Need of Repair," *Proceedings of ASHRAE/DOE/BTECC/CIBSE Conference on Thermal Performance of the Exterior Envelope of Buildings IV*," December 4-7, 1989. Available from ASHRAE, Atlanta, GA, USA.

Single Ply Roofing Institute, "A Method to Determine the Suitability of Recovering an Existing Moisture," presented at the 1992 Roofing Consultants Institute Convention, March 16-18, 1992.

Tobiasson, W., C. Korhonen, B. Coutermarsh, and A. Greatorex, "Can Wet Roof Insulation Be Dried Out?" in ASTM Special Technical Publication 789, *Thermal Insulation, Materials and Systems for Energy Conservation in the '80's*, 1983, American Society for Testing of Materials, Philadelphia, PA.

Tobiasson, W., "Vents and Vapor Retarding for Roofs," in Symposium on Air Infiltration, Ventilation, and Moisture Transfer, December 2-4, 1986. Available from Building Thermal Envelope Coordinating Council, Washington, DC.

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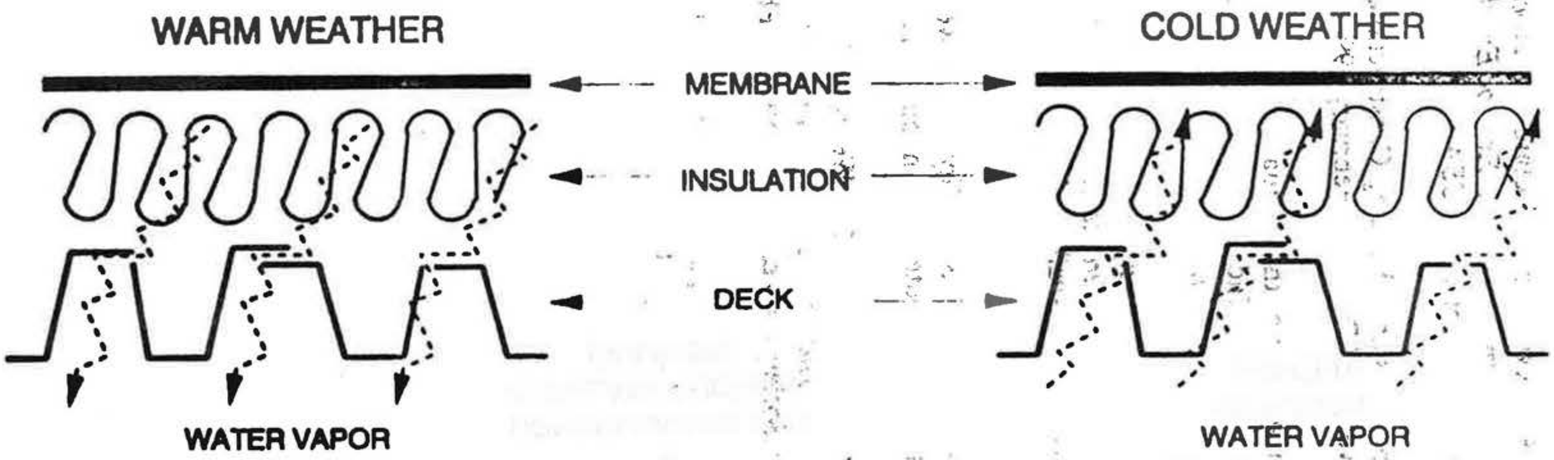
CLIMATE EFFECT ON ROOF MOISTURE



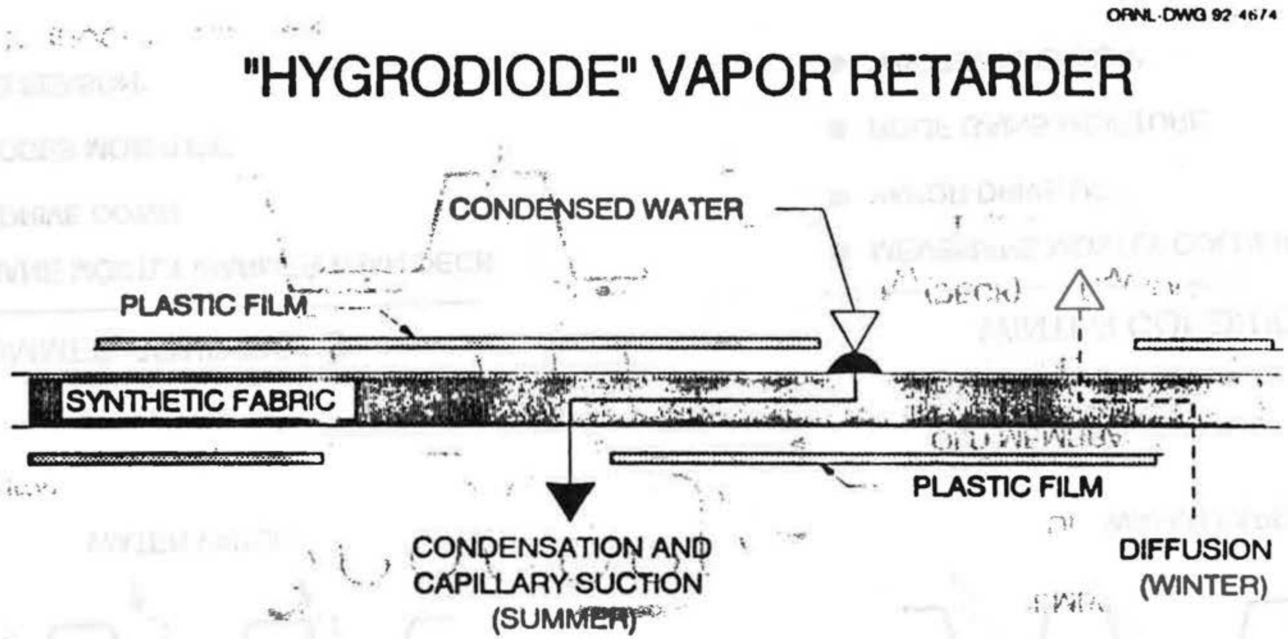
SUMMER CONDITIONS

- MEMBRANE MOSTLY WARMER THAN DECK
- VAPOR DRIVE DOWN
- ROOF LOSES MOISTURE
- "DRYING SEASON"

WINTER CONDITIONS

- MEMBRANE MOSTLY COLDER THAN DECK
- VAPOR DRIVE UP
- ROOF GAINS MOISTURE
- "WETTING SEASON"

Fig. 1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"HYGRODIODE" VAPOR RETARDER
CONDENSED WATER
PLASTIC FILM
SYNTHETIC FABRIC
PLASTIC FILM
CONDENSATION AND
CAPILLARY SUCTION
(SUMMER)
DIFFUSION
(WINTER)

Fig. 2

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DOWNWARD DRYING OF OLD ROOF INSULATION AFTER RECOVERY

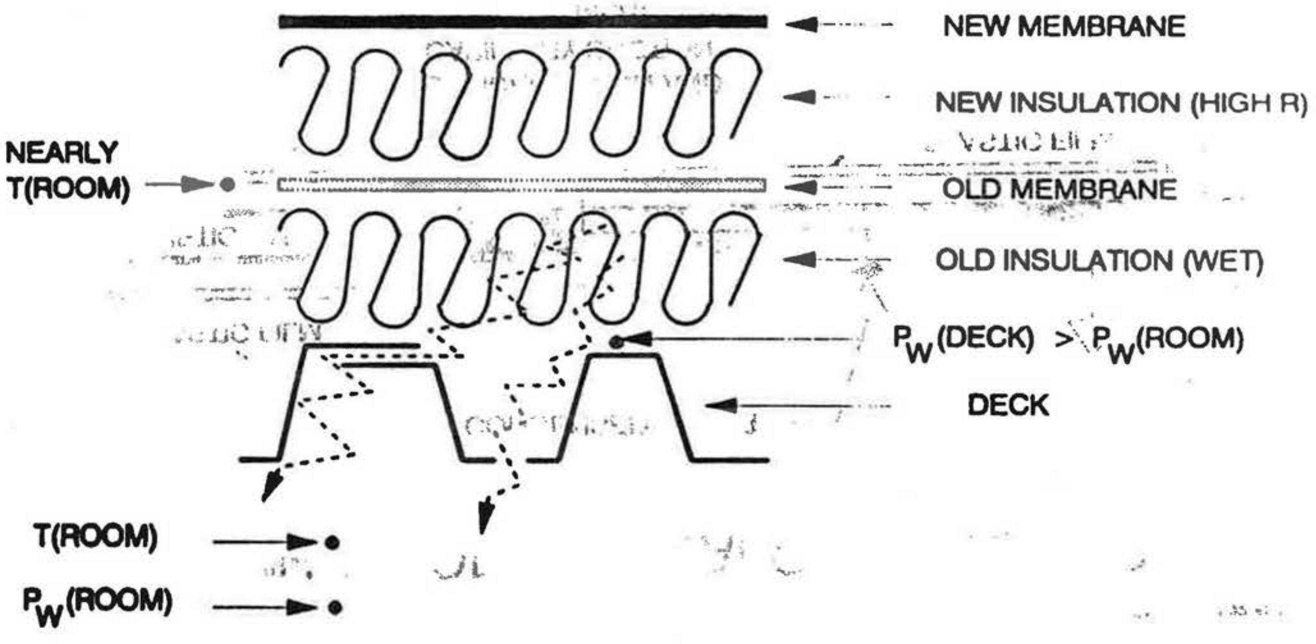

Fig. 3