

collectors employing EPDM mats of the three types available, so that within fairly narrow limits the tube sizes and spacings are not critical. The arrangement of Fig. 1*b* should be a better collector than that of Fig. 1*c*, since it should result in a more even temperature distribution over the collector plate and hence a reduced heat loss. The results indicate a possible reduction in heat loss, but since this reduction fell within the experimental error of the measurements this conclusion cannot be made. However, in large roof mounted collectors there may be practical advantages in installing the inlet and return manifolds, either as in Fig. 1*b* or 1*c*, and either may be used with little change in the end result.

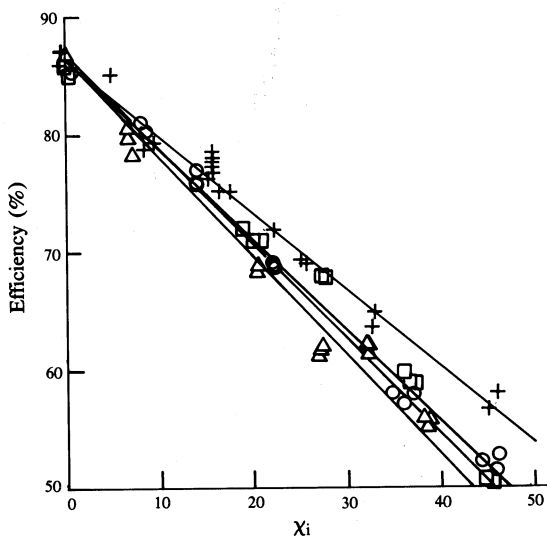


Fig. 2. Efficiency of an EPDM collector as a function of $\chi_i = (T_i - T_e)/G$ for four different flow rates: crosses, $F'' = 0.94$; squares, $F'' = 0.93$; circles, $F'' = 0.91$; and triangles, $F'' = 0.84$.

Fig. 2 shows a typical set of efficiency curves for an EPDM collector at four different mass flow rates. It can be seen that the results are in accord with the theory (see equations 2 and 3). The gradient of the curves gives the heat loss coefficient and the result here of about $7.0 \text{ W m}^{-2} \text{ K}^{-1}$ is similar to that for single-glazed metal collectors (Duffie and Beckman 1980). The heat loss is independent of temperature but shows a dependence on mass flow rate, as discussed below. The similarity to metal collectors is quite remarkable. For example, the incident angle modifier coefficient found for the EPDM collectors was $b = 0.09$ in accord with that predicted for metal collectors of similar geometry (Duffie and Beckman 1980). The explanation lies in the fact that although EPDM has a poor thermal conductance the heat path to the collector fluid is still of much lower resistance than the heat loss path. This heat loss is mainly due to radiation which is inhibited by the glazing.

The variation of the heat loss coefficient with the flow factor is shown in Fig. 3 for three different collectors. The sharp drop in the heat loss coefficient at flow factors of about 0.95 is difficult to explain and this feature is not present with all-metal collectors. While a steady drop in heat loss with increasing mass flow is to be expected, there is at present no mechanism to explain the sharp drop at one particular

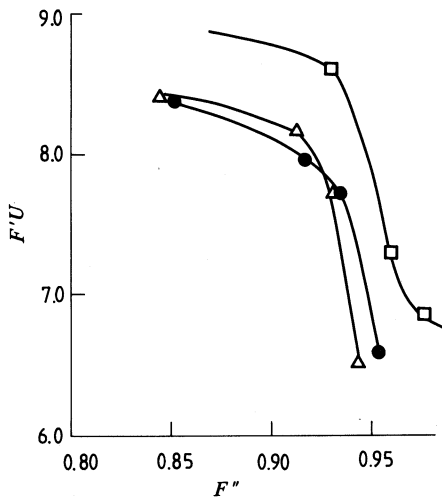


Fig. 3. Heat loss $F'U$ as a function of the flow factor F'' for three different EPDM collectors.

flow value. The drop is not due to a transition from laminar to turbulent flow of the heat transfer fluid. The Reynolds number R_e for the flows reported here is typically about 500. The transition to turbulent flow would occur for $R_e > 2000$.

The explanation given here arises out of a concurrent investigation (O'Keefe and Francey 1986) into the flow distribution within the riser tubes of the collector. It was noted that at flow factors smaller than 0.95 there was air present in the riser tubes—some of these were transparent for investigation of the flows. The air of course formed pockets above the fluid and immediately under that part of the riser facing incoming solar radiation. Thus, the top part of the riser will move to a temperature higher than parts further round a circumference, the high resistance of the EPDM supporting the thermal gradient. The higher temperature leads to a higher heat loss. Metal risers on the other hand are isothermal. At flow factors above 0.95 the air pockets disappear but reform when the flow factor is again reduced. A flow factor of 0.95 corresponds to a flow rate of about $15 \text{ gs}^{-1} \text{ m}^{-1}$ and care must be taken to maintain flow rates above this if the best results are to be obtained from these collectors.

As mentioned above, a large collector 480 m^2 in area is operating on the roof of the Monash University swimming pool and this collector was one of the 15 tested. The performance of this collector has been reported elsewhere (Francey *et al.* 1985), but a small (2.0 m^2) section of the large collector was tested independently in an effort to predict the performance characteristics of such large collectors. The roof top collector has EPDM mats glued directly to the metal roof but sitting in depressions between metal ribs over which is placed the acrylic sheet glazing. This gives a plate to top cover gap of 4 cm and results in some shading of the plate. This gave an incident angle modifier coefficient of 0.172 for the pool collector. The small scale model, which also had 4 cm side walls, gave a coefficient of 0.169. The optical efficiency ($F'K\tau\alpha$) for the large collector was 0.74, while for the small model this was 0.76. Thus, excellent agreement was reached between the two.

6. Conclusions

In spite of the high thermal resistance of EPDM, solar collectors using flat plates and risers formed from this material give results comparable with all-metal tube and

fin collectors. Care must be taken to maintain an adequate flow of heat transfer fluid within EPDM collectors. Scale models of large solar collector installations can predict their expected performance.

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