AEES–3

ENERGY FACT SHEET

AIR-TYPE SOLAR COLLECTORS FOR AGRICULTURAL AND RESIDENTIAL USE

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This publication provides information on three basic air-type solar collectors for the purpose of explaining the characteristics of each. The collectors may be purchased assembled or constructed on the site. In either case an efficient collector of the right type should be selected for a given application.

If you are constructing a collector, you should know that the efficiency is greatly influenced by the design of the unit as well as the construction materials and assembly. One of the major problems of constructing air-type solar collectors on the site is the lack of good design. Design includes selecting a type of collector, the materials for construction and computation of pressure drop through the collector and heat transfer within the collector. These problems should be done by an engineer who has knowledge of properties of transparent and absorptive materials and experience in heat transfer of solar collectors.

Three types of solar air heaters are illustrated in Figure 1. The dashed line represents one or more transparent covers. Type I uses the "flow over the absorber." Type II utilizes "flow on both sides of the absorber" and Type III, "flow under the absorber." Type III may also be constructed without a transparent cover. This form of Type III is known as the bare plate collector. Such a collector has a rather low efficiency and output temperature but it can be constructed at low cost by flowing air within a space underneath the roof of a building.

A solar collector has two functions: (1) absorb solar radiation and (2) transfer the heat from the absorber plate to the transport fluid (air in this case). In all air-type collectors the flow of the transport fluid should be restricted so as to create a high flow velocity against the solar absorber plate. The flow velocity will usually be 10 to 12 ft/sec. or higher. Thermosiphoning air-type collectors (in which the airflow is by natural convection) must be very tall to cause a 10 ft/sec. rate of airflow. Therefore, height is needed (16 feet or more) to achieve good efficiency with a thermosiphoning air-type collector.

The types of collectors illustrated will operate at various efficiencies and output temperatures depending upon their design, construction, rate of solar radiation, outside temperature, wind velocity, air velocity in the collector, and flow rate of air per unit area of collector. It is difficult to provide specific information on solar air heaters. However, we can compute collector performance (efficiency and output temperature) provided the collector is of a fixed design and the weather conditions are stated. To illustrate the performance range of the three basic types of collectors, the computed performance curves of Figures 2 through 7 are presented. IT MUST BE RECOGNIZED THAT PERFORMANCE OF THESE COLLECTORS HAS BEEN COMPUTED AS AN EXAMPLE OF EACH TYPE. The results shown in the figures can be used as a guide to the general range of output temperatures and efficiencies which can be expected of each type of collector since the computations are for typical collectors.

HEATING AMBIENT AIR

Since there are several agriculture applications, such as grain drying and heating of ventilation air for animal structures, where outside ambient air is to be heated, it is desirable to understand the performance of a solar air heater when heating ambient air.

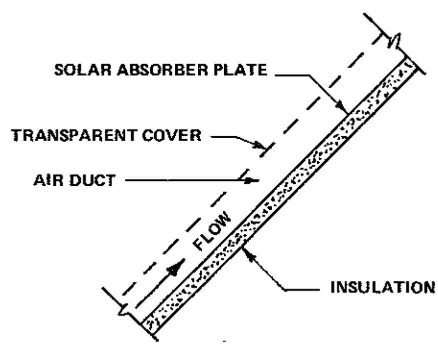
Figures 2, 3 and 4 illustrate Type I, Type II, and Type III collectors, respectively, with single and double covers when these collectors are used for heating ambient air (air which surrounds the collector). CAUTION: In designing these collectors for heating ambient air each flow rate actually represents a different collector since the size of the flow duct for the air passing through the collector must be increased as the flow volume increases in order that the heat transfer rate from the absorber plate to the air stream remains a constant for each of the flow rates illustrated. Do not interpret these figures as the same collector

For instance, even with an outside ambient temperature of 40F, the single cover Type I collector (flow over the absorber) will barely produce 30 degrees above the input temperature of 70°F with the highest solar radiation rates. With 30 degree temperature rise the output temperature is only 100°F, which is minimum for heating a residence. The Type I collector with a single cover would be a very inappropriate choice for heating a residence. The single cover collector with flow on both sides of the absorber shows some improvement as compared with Type I but the collector with flow under the absorber (Type III) performs best of the single cover collectors. Each of the collectors are significantly improved in terms of temperature rise by adding a second cover plate. In fact, two covers should be used for residential heating.

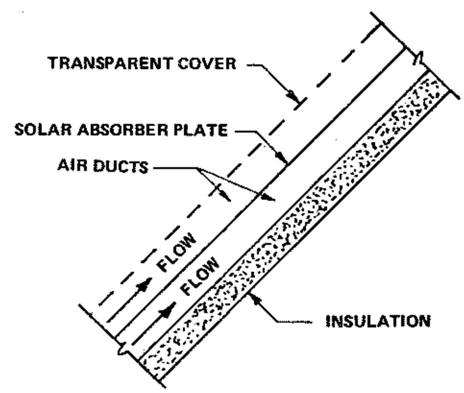
A selective absorber is sometimes used for higher temperature collectors, such as for residential use. None of the collectors in this publication have a selective surface, i.e., an absorber which will absorb solar radiation at a high rate but will emit thermal radiation at a low rate. The selective surface coating on an absorber will improve the performance of a collector, particularly, a single cover collector. However, selective absorbers are still rather costly and some of them deteriorate in use.

SUMMARY

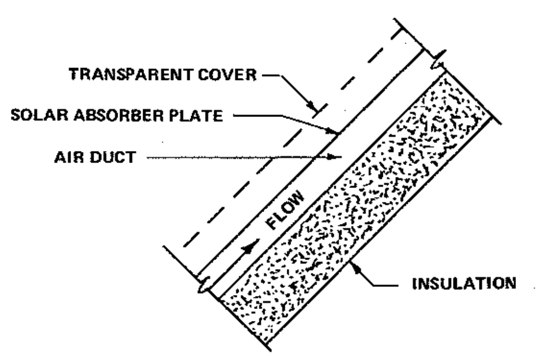
Three types of solar air heaters are presented which utilize flow over the absorber, flow both sides of the absorber, and flow under the absorber, respectively. Using typical good design information for each of these types, the performance of each collector type has been computed for heating ambient air (that is, heating the air surrounding the collector) and for heating 70°F air. The computed data for each of the collector types illustrated is restricted to that type collector and to specific environmental and flow conditions. The data should be used only to provide a concept of trends which are generally applicable to each of the respective types of flat plate collectors. These data provide understanding of the three basic air-type collectors which should be useful as a general guide for selecting a collector type. The data presented must not be used for design but rather a specific design for such application should be made by an experienced engineer.



TYPE I, FLOW OVER ABSORBER



TYPE II, FLOW BOTH SIDES OF ABSORBER



TYPE III, FLOW UNDER ABSORBER

FIG. 1. AIR-TYPE COLLECTORS

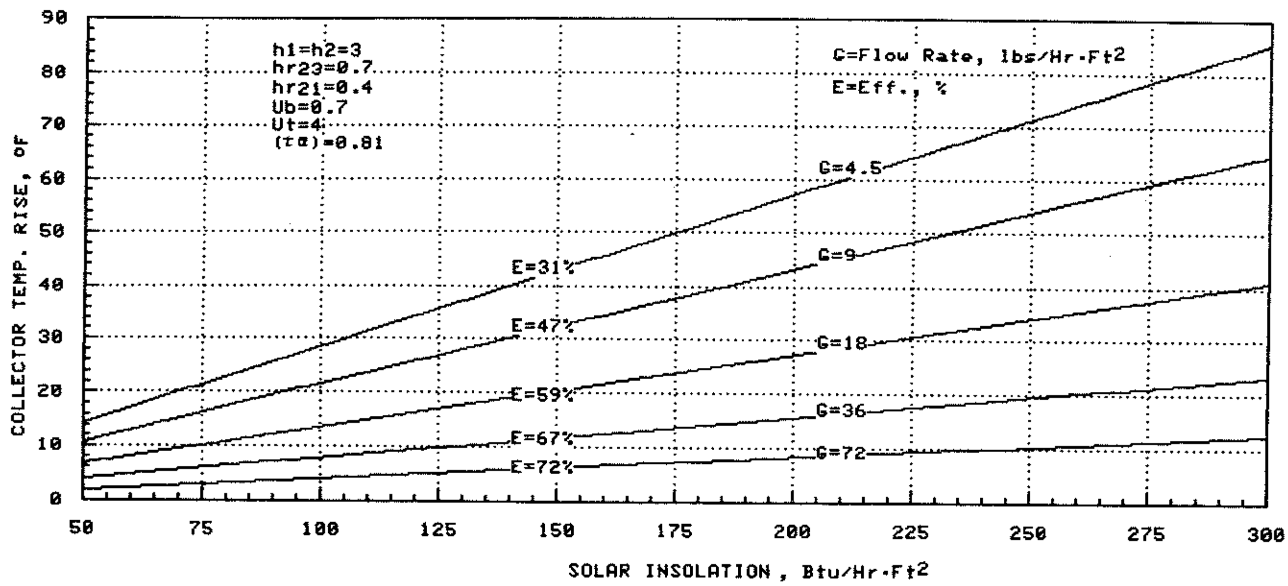


FIG. 3a. COMPUTED PERFORMANCE FOR SINGLE COVER SOLAR AIR HEATER WITH FLOW BOTH SIDES OF ABSORBER, HEATING AMBIENT AIR

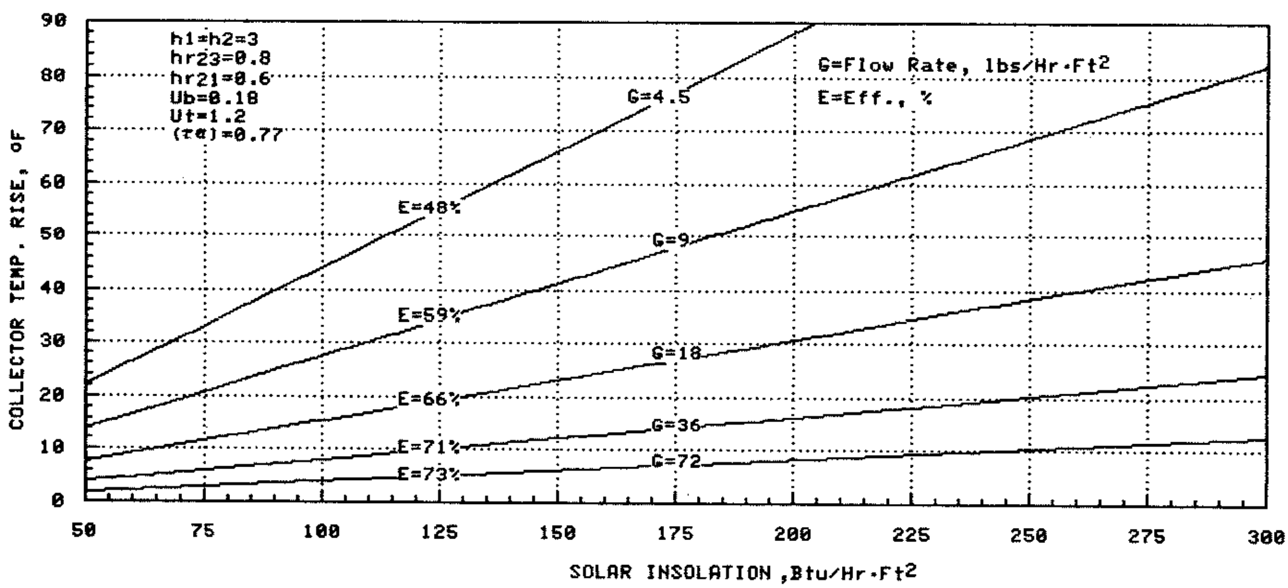


FIG. 3b. COMPUTED PERFORMANCE FOR DOUBLE COVER SOLAR AIR HEATER WITH FLOW BOTH SIDES OF ABSORBER, HEATING AMBIENT AIR

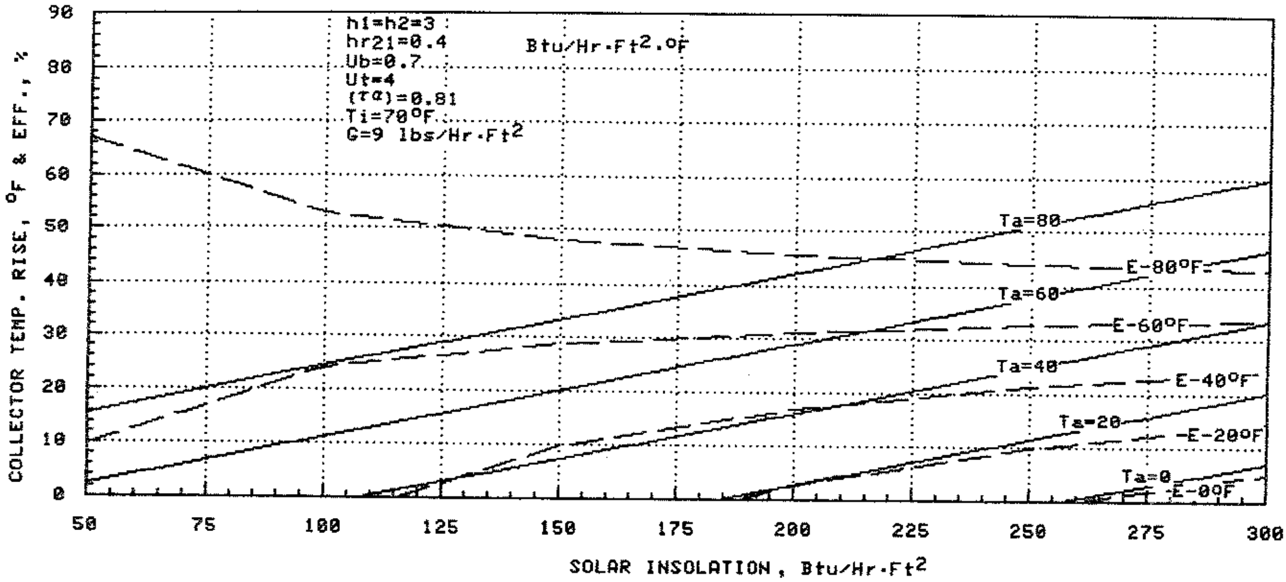


FIG. 5a. COMPUTED PERFORMANCE FOR SINGLE COVER SOLAR AIR HEATER WITH FLOW OVER THE ABSORBER, HEATING 70°F AIR

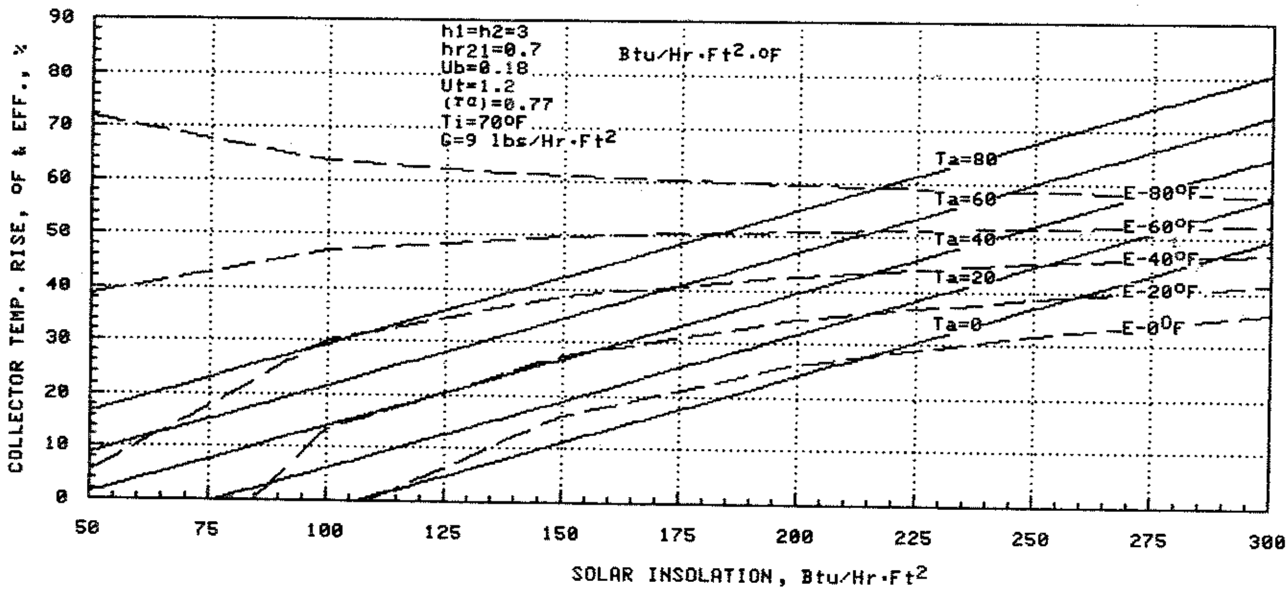


FIG. 5b. COMPUTED PERFORMANCE FOR DOUBLE COVER SOLAR AIR HEATER WITH FLOW OVER THE ABSORBER, HEATING 70°F AIR

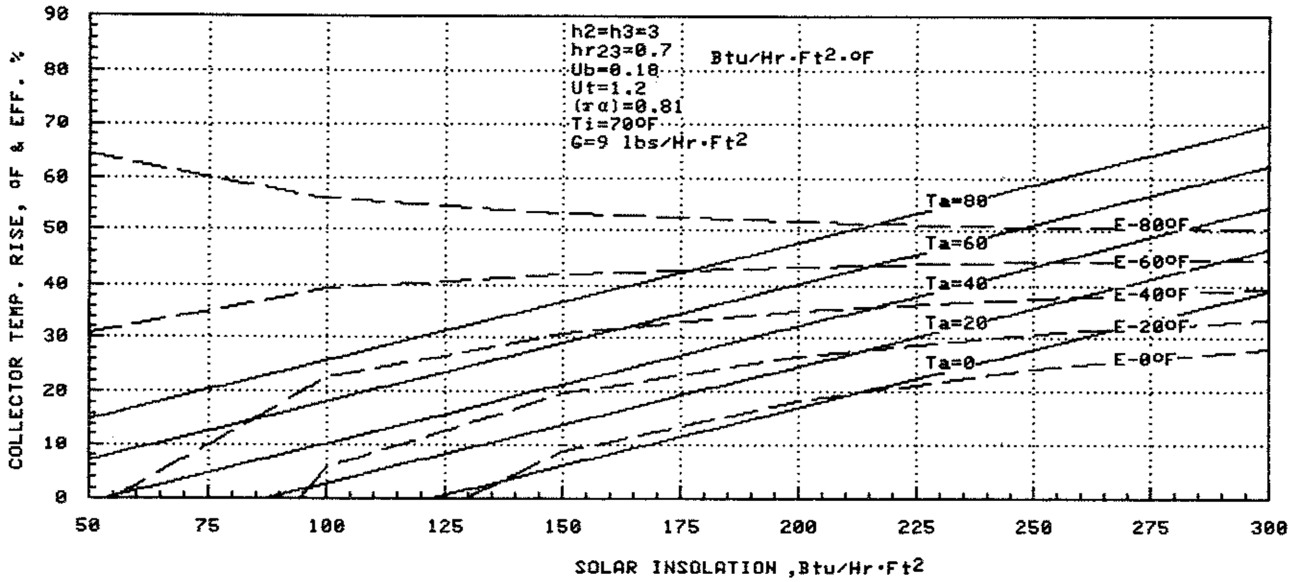


FIG. 7a. COMPUTED PERFORMANCE FOR SINGLE COVER SOLAR AIR HEATER WITH FLOW UNDER THE ABSORBER, HEATING 70°F AIR

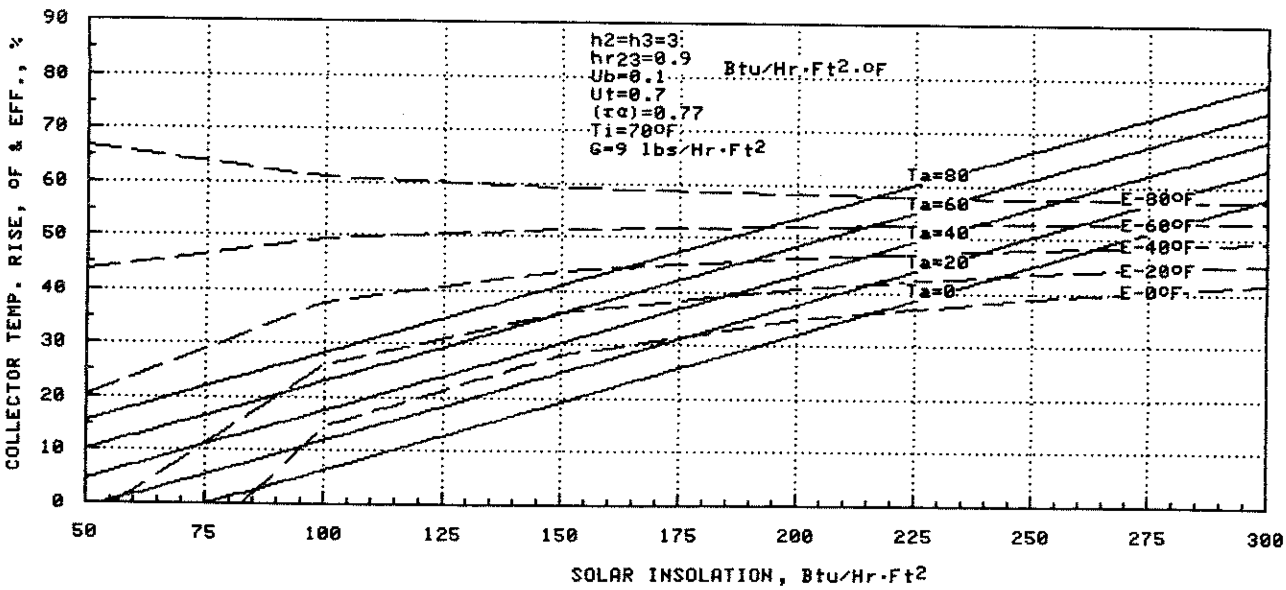


FIG. 7b. COMPUTED PERFORMANCE FOR DOUBLE COVER SOLAR AIR HEATER WITH FLOW UNDER THE ABSORBER, HEATING 70°F AIR

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