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STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY - AN EVACUATED FLAT-PLATE COPPER COLLECTOR WITH A SERPENTINE FLOW DISTRIBUTION

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16. Abstract

This preliminary data report gives basic test results of a flat-plate solar collector whose performance was determined in the NASA-Lewis solar simulator. The collector was tested over ranges of inlet temperatures, fluxes and one coolant flow rate. Collector efficiency is correlated in terms of inlet temperature and flux level.

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Lewis Research Center

INTRODUCTION

An area that has been investigated by the NASA Lewis Research Center in its efforts to aid in the utilization of alternate energy sources is the use of solar energy for the heating and cooling of buildings. An important part of this effort was the evaluation of solar collectors which have the potential to be efficient, economical, and reliable.

This preliminary data report gives basic test results of a collector whose performance was determined in the NASA-Lewis solar simulator. In the interest of providing performance data on this collector to the technical community as quickly as possible, the basic test results reported herein are presented without evaluation. Detailed analyses and interpretation of these results may be presented in subsequent papers or reports by this Center. Some of the results contained in this report may be changed as warranted by reviews and evaluations, or by obtaining additional data on this collector.

Reference 1 describes the solar-simulator test facility, as well as the basic test procedure.

COLLECTOR DESCRIPTION

The Solarvak flat plate solar collector was manufactured by Solar Systems, Inc. of Tyler, Texas. The collector is designed to be evacuated but the particular collector tested had an internal pressure only slightly less than atmospheric (28.5 inches of mercury). Wooden dowels separate the 1/4 inch thick acrylic top and bottom sheets. These two acrylic sheets form the box-like construction of the collector with nuts and bolts holding the assembly together at the flanges. The absorber plate is copper with a selective surface copper oxide coating and is suspended and held in place by several 1 inch diameter wooden dowels. The fluid flow is serpentine configuration with 3/8 inch

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O.D. copper tubes soldered to the underside of the absorber plate. Aluminum foil is placed on the bottom and directly behind the flow tubes to reduce energy lost by radiation from the back of the absorber plate. No insulation is present in the collector. A photograph of the collector on the test stand is shown in figure 1.

COLLECTOR TEST RESULTS

Basic test results are given in Table I. Since this collector was larger than the area of radiation provided by the solar simulator, it was necessary to use a "shield" approach as explained in Reference 1. This technique allows one to determine the efficiency of the entire collector even though only a portion of it is actually exposed to radiation. By using the analytical method outlined in Reference 1 for a collector tested with a "shield", the results given for the flow rate in Table I were used for a determination of the performance correlation given in Figure 2.

In addition to the basic test performed on the collector, a series of incident angle tests were run to help predict changes of sun incidence angles thoughout the period of one solar day. Table II lists the collector efficiency at various rotation and incident angles, along with $K_{\alpha\tau}$ values. One analytical method for interpreting and using these data can be found in Reference 1.

REFERENCES

1. Simon, Frederick F.: Flat-Plate Collector Performance with a Solar Simulator as a Basis for Collector Selection and Performance Prediction. NASA TMX-71793, 1975.

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TABLE I - BASIC EXPERIMENTAL DATA

50/50 Water and Ethylene Glycol
Incident Angel = 0°
Tilt Angle = 57° Above Horizontal

Flow Per Radiated Surface Area lb/hr ft^2	Flow Gal/Min	Incident Radiation Flux Btu/hr ft^2	Fluid Outlet Temp., °F	Fluid Inlet Temp., °F	Ambient Temp.	Efficiency
19.305	0.49469	202.27	96.447	85.993	84.144	0.81975
19.370	0.49620	195.31	97.675	85.538	83.659	0.58080
19.157	0.50251	195.08	126.22	120.39	80.897	0.47981
19.141	0.50281	287.41	130.09	120.89	81.416	0.51403
19.222	0.50610	194.23	165.66	161.94	79.390	0.31617
19.271	0.50612	292.82	168.11	161.16	79.834	0.39142

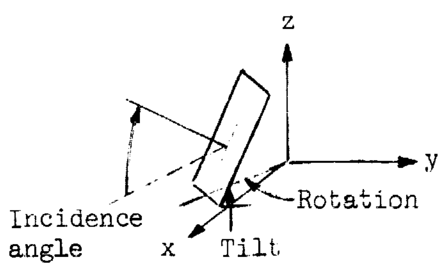
TABLE II. - INCIDENT ANGLE MODIFIER DATA

Tilt[a] angle, deg	Rotation angle, deg	Incidence angle, deg	Efficiency	$K_{\alpha\tau}$
57	0	0	0.820	1.0
57	50	41.5	0.816	0.995
57	70	57.5	0.769	0.938
57	80	65.2	0.720	0.878

[a]Tilt angle - the angle between the horizontal and the plane of the collector.

Rotation angle - the angle that is measured in relation to the X-axis when the collector is rotated around the Z-axis.

Incidence angle - the angle that is measured between the beam of light and the normal to the plane of the collector.



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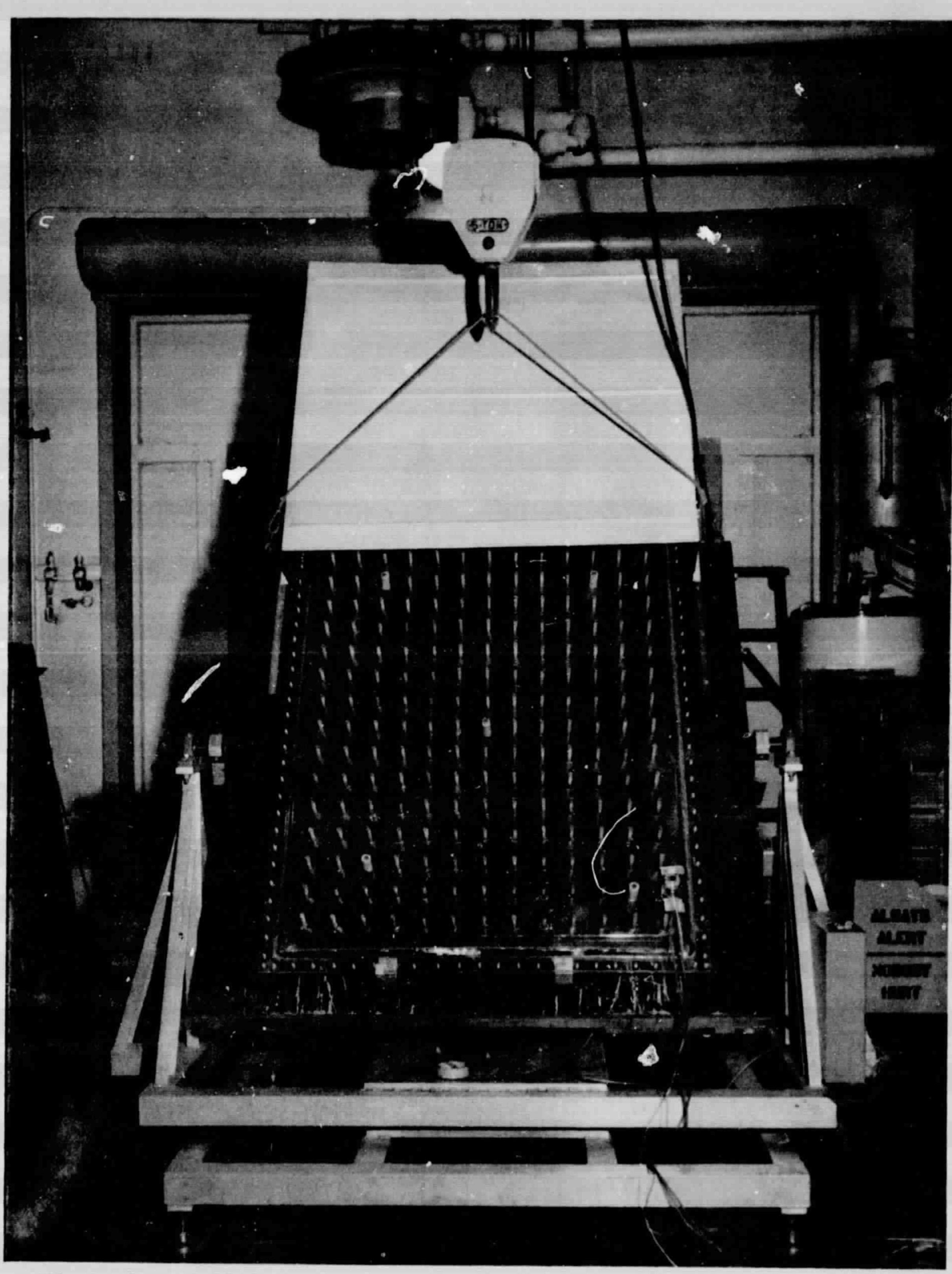

Figure 1. - Collector on Test Stand

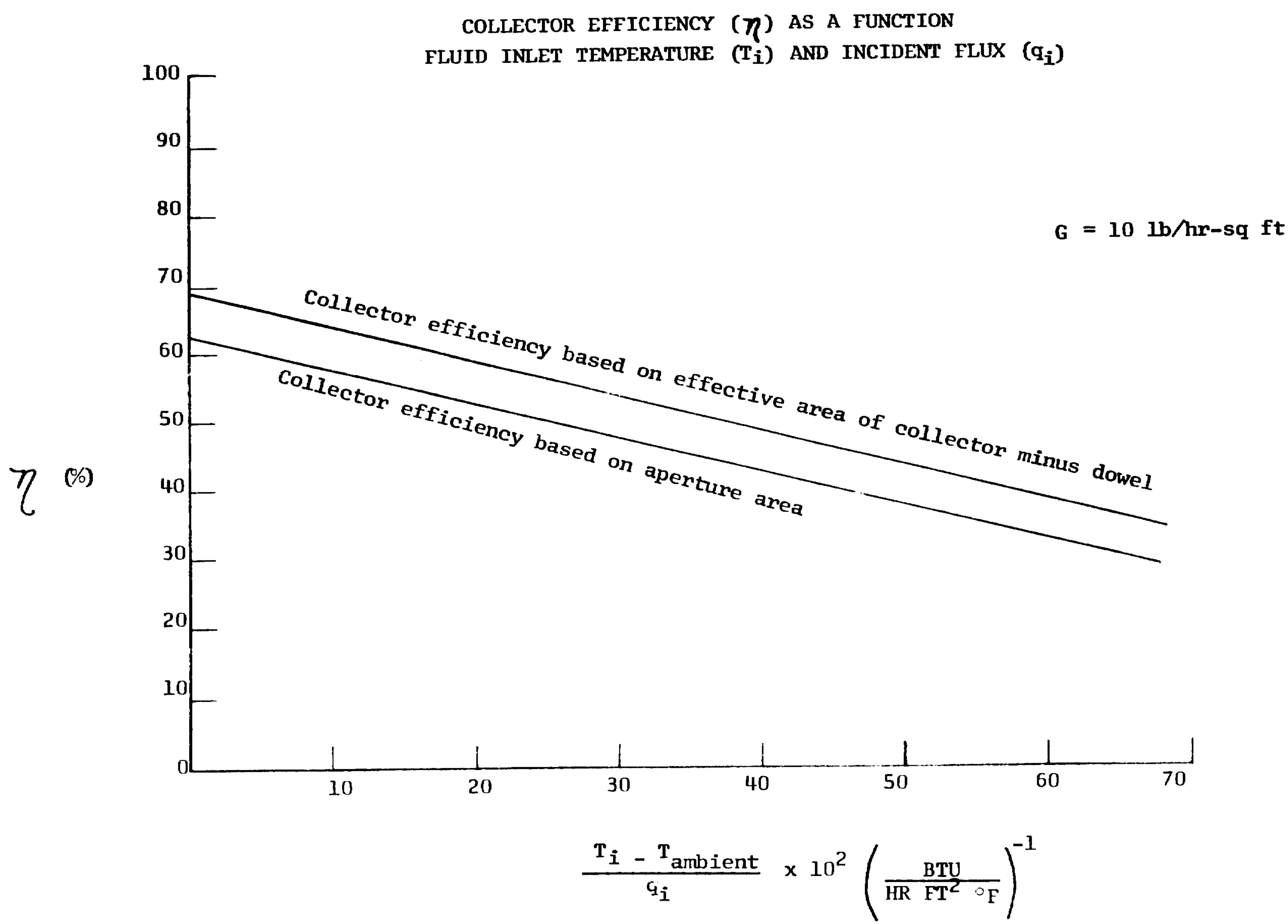

Figure 2. - Collector Performance Correlation