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Midtemperature Solar Systems Test Facility Predictions for Thermal Performance of the Acurex Solar Collector With Fek 244 Reflector Surface

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MIDTEMPERATURE SOLAR SYSTEMS TEST FACILITY PREDICTIONS FOR THERMAL PERFORMANCE OF THE ACUREX SOLAR COLLECTOR WITH FEK 244 REFLECTOR SURFACE

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ABSTRACT

Thermal performance predictions are presented for the Acurex solar collector, with FEK 244 reflector surface, for three output temperatures at five cities in the United States.

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MIDTEMPERATURE SOLAR SYSTEMS TEST FACILITY PREDICTIONS FOR THERMAL PERFORMANCE OF THE ACUREX SOLAR COLLECTOR WITH FEK 244 REFLECTOR SURFACE

Introduction

Sandia National Laboratories, Albuquerque (SNLA), is currently conducting a program to predict the performance and measure the characteristics of commercially available solar collectors that have the potential for use in industrial process heat and enhanced oil recovery applications. A detailed account of the methods used to make the predictions is given in Reference 1. For the convenience of the reader, some of this information is repeated in this document. This document presents the thermal performance predictions for the Acurex solar line-focusing collector. The program is limited to thermal performance only and does not include consideration of other factors, such as

1. Losses at the ends, at gaps, and from shadowing due to packing,
2. Collector warm-up penalties,
3. Degradation of performance,
4. Cost of the collector,
5. Losses in the energy transport system and system warm-up penalties,
6. Reliability,
7. Cost of installation,
8. Cost of operation and maintenance, and
9. Wind effects.

The program is authorized by the Department of Energy, Division of Solar Thermal Energy Systems, and partially funded through the Solar Energy Research Institute.

Description of the Collector

A photograph of the Acurex solar collector is shown in Figure 1. The module has the following characteristics.

Reflector configuration	Parabolic trough
Reflective surface	FEK 244
Aperture dimensions	1.80 m x 6.10 m (5.9 ft x 20 ft)
Aperture area	10.98 m^2 (118 ft^2)
Support structure	Sheet metal with steel ribs connected to steel pipe backbone
Tracking system	Shadow band (Acurex)
Drive mechanism	Electric
Heat transfer fluid	Therminol-66®
Operating range	100° to 300°C (212° to 572°F)
Manufacturer	Acurex Corporation 485 Clyde Ave. Mountain View, CA 94042

Results of the Test Program

This collector was tested at the Collector Module Test Facility (CMTF) at SNLA. From the test data, three parameters were defined.

1. Peak efficiency (η_p) -- the efficiency of the collector, when the sun's rays are at normal incidence to the aperture plane (equivalent to solar noon) expressed as a function of $\Delta t/I$. Δt is the temperature difference between the heat transfer fluid outlet temperature and the ambient temperature in degrees Centigrade. I is the irradiance of the sun in watts per square meter.

$$\eta_p = 64.0 - 9.86\ \Delta t/I - 141.4\ (\Delta t/I)^2\ .\ (\%)$$

Peak efficiency is plotted in Figure 2.

2. Receiver thermal loss (Q_L) -- the heat lost per unit aperture area expressed as a function of Δt.

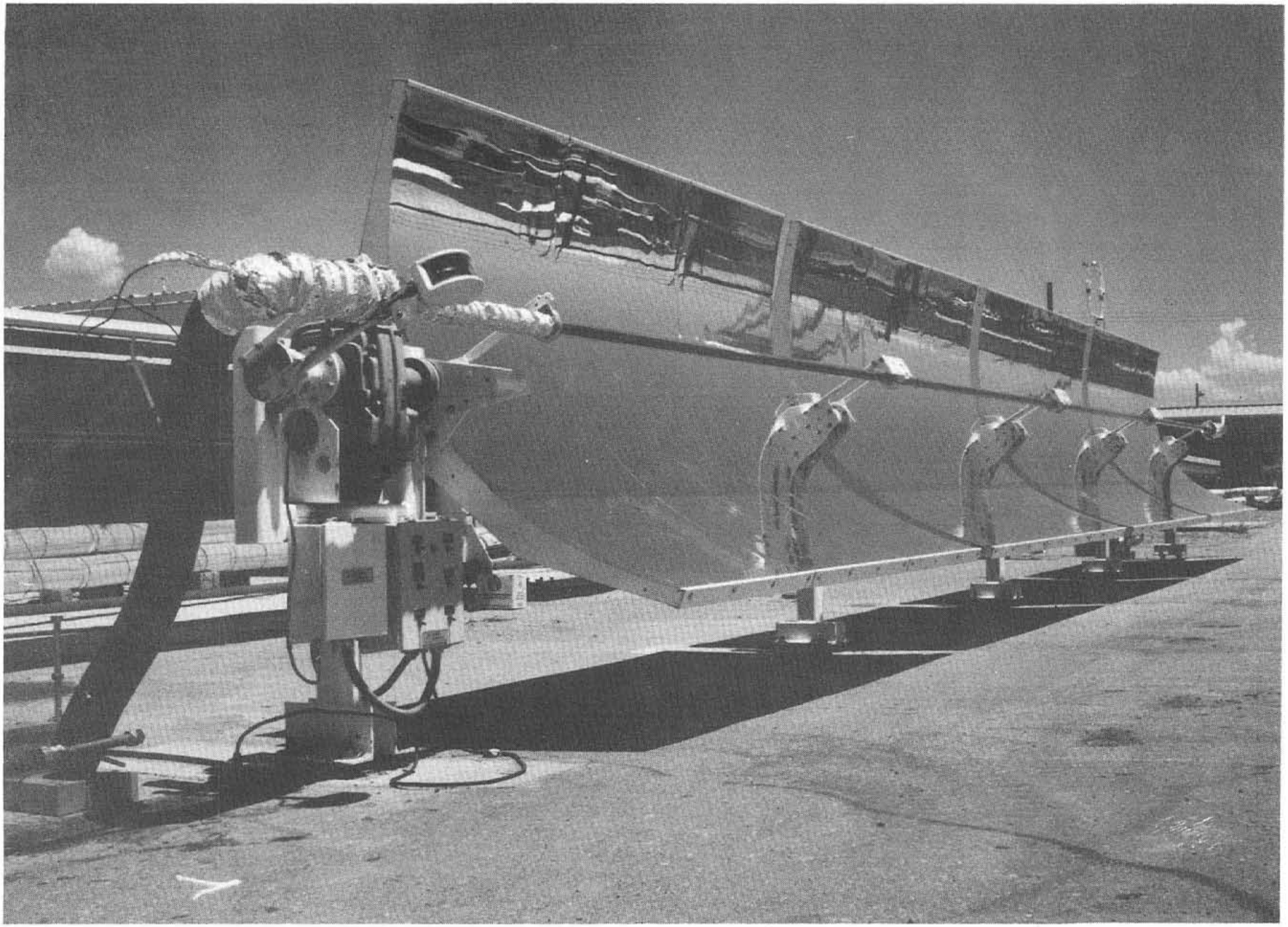

Figure 1. Acurex Solar Collector

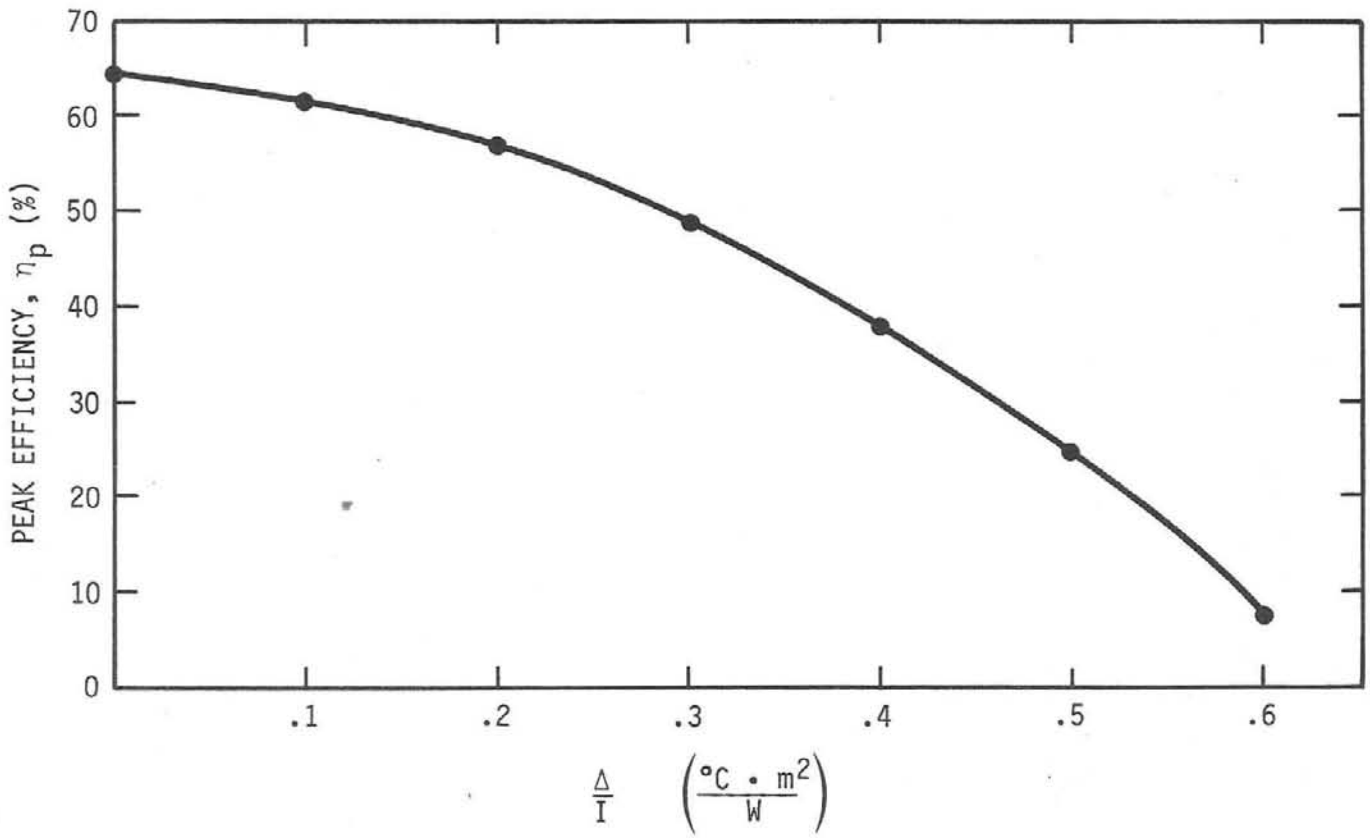

Figure 2. Peak Efficiency Plot for the Acurex Solar Collector with FEK 244 Reflector Surface

$$Q_L = 0.0139 + 0.0639\ \Delta t + 0.00172(\Delta t)^2\ .\ (W/m^2)$$

Heat loss is plotted in Figure 3.

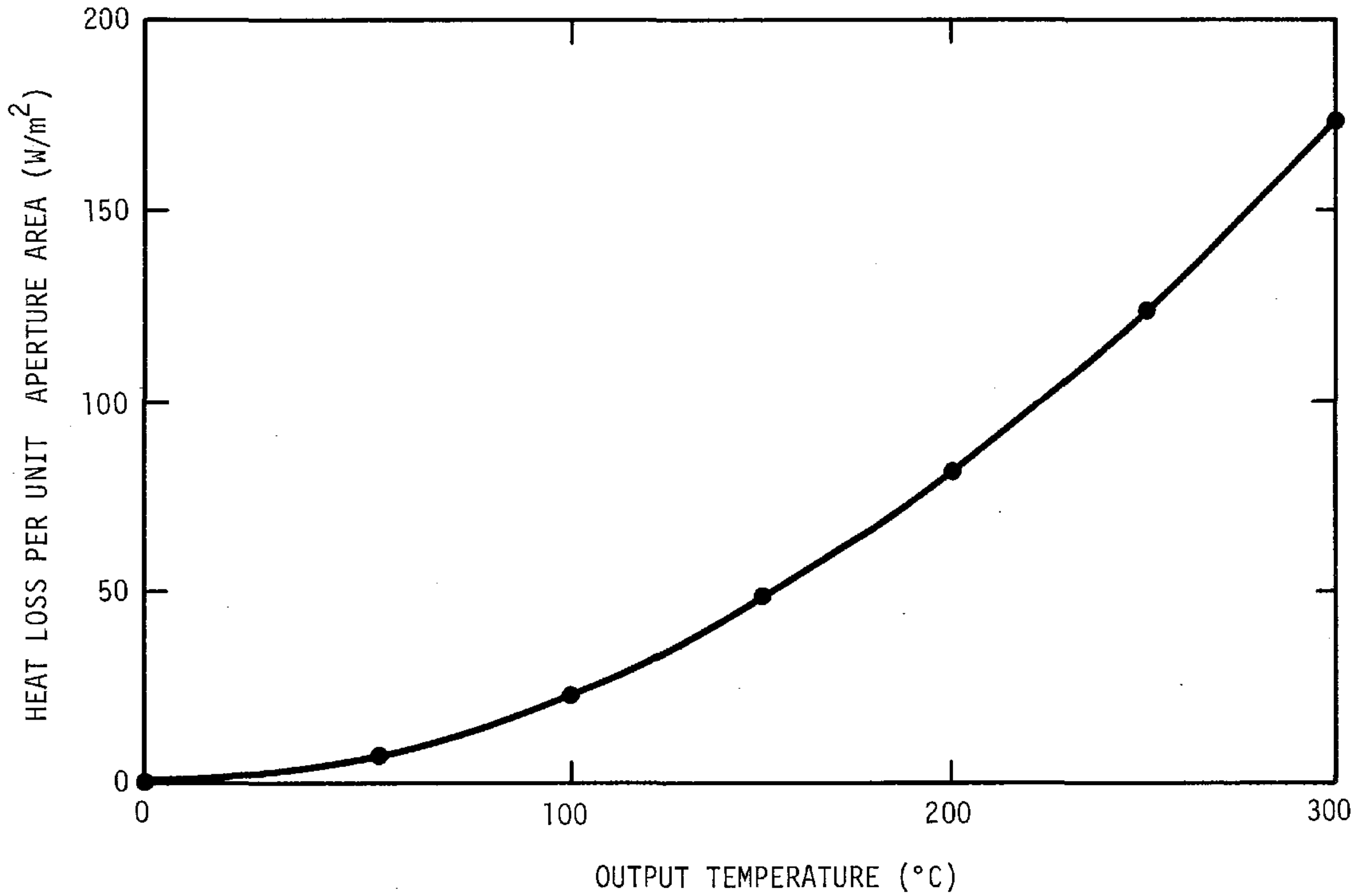

Figure 3. Heat Loss Plot for the Acurex Solar Collector with FEK 244 Reflector Surface

3. Optical loss coefficient (K_O) -- K_O, in conjunction with the end-loss coefficient, K_E, and the "cosine effect," determine the incident angle modifier, K. Specifically, $K = K_O K_E \cos\theta$. See Reference 1.

The values of K_o as a function of θ are

θ (degrees)	K_o	θ (degrees)	K_o
0	1.00	40	0.90
10	1.00	50	0.84
20	0.97	60	0.70
30	0.96	70	0.53

Prediction of Thermal Performance

A computer program calculates the predicted thermal performance of the collector. The performance parameters defined above are the input data describing the collector while solar and weather data are provided by TMY data tapes. With this input, the computer program calculates the thermal output of the collector for each month of the TMY in units of kilowatt hours per square meter (kWh/m^2) of collector aperture area. This calculation was made for five locations: Fresno, California; Albuquerque, New Mexico; Fort Worth, Texas; Charleston, South Carolina; and Boston, Massachusetts. Three different collector output temperatures and both E-W and N-S orientations were considered. Figures 4 through 8 are graphical displays of the results of the computer prediction. These figures show the monthly thermal output ($kWh/m^2 \cdot mo$) for each location, output temperature, and orientation. The monthly outputs have been summed to give the annual output for each parameter variation, and the results are shown in Table 1. The computer predictions assume 1 square meter of aperture area in the middle of a row of infinite length, with no end or gap losses and no shadowing due to packing.

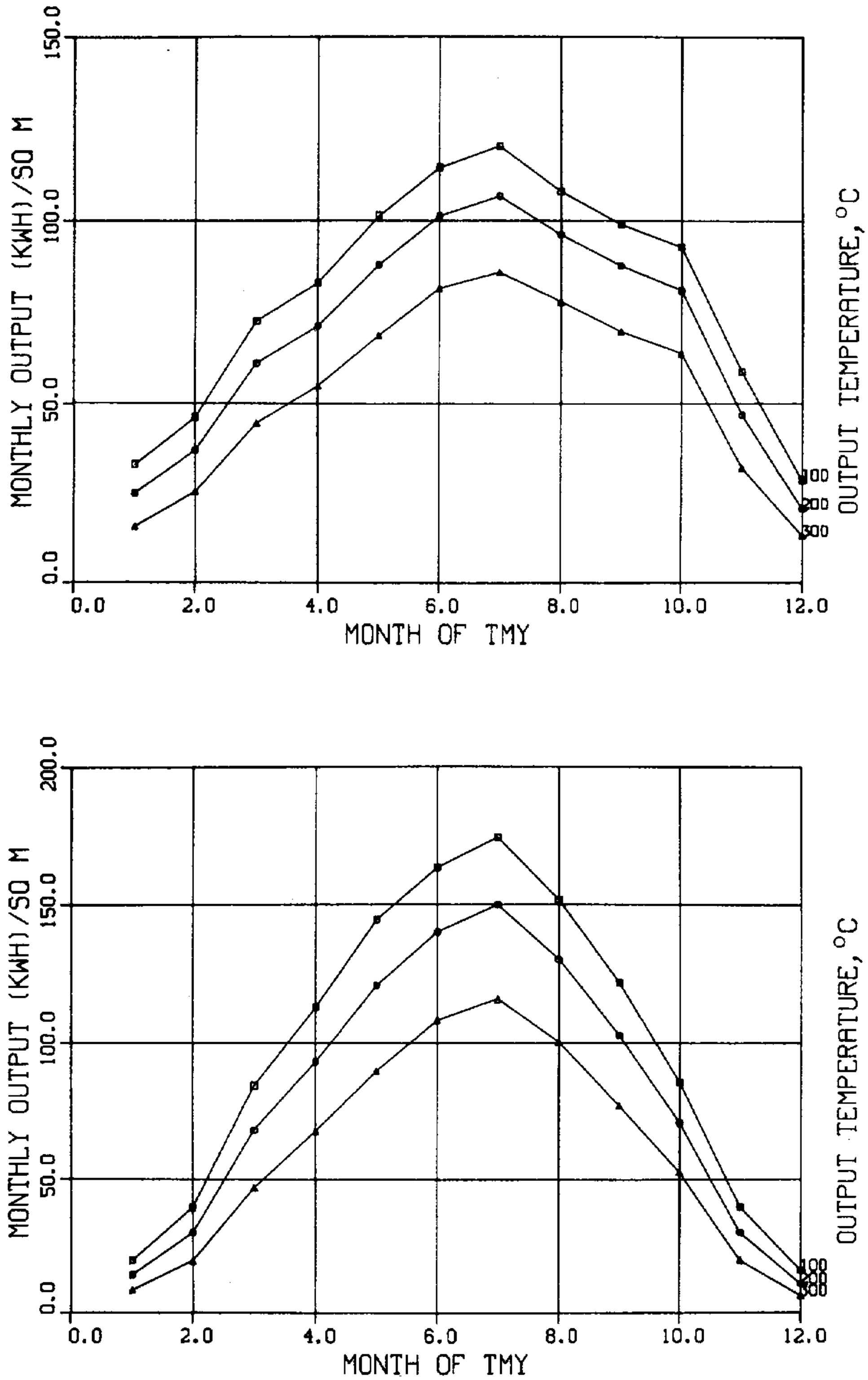

Figure 4. Thermal Output of the Acurex Solar Collector with FEK 244 Reflector Surface with E-W and N-S Orientation and Fresno TMY Solar Data

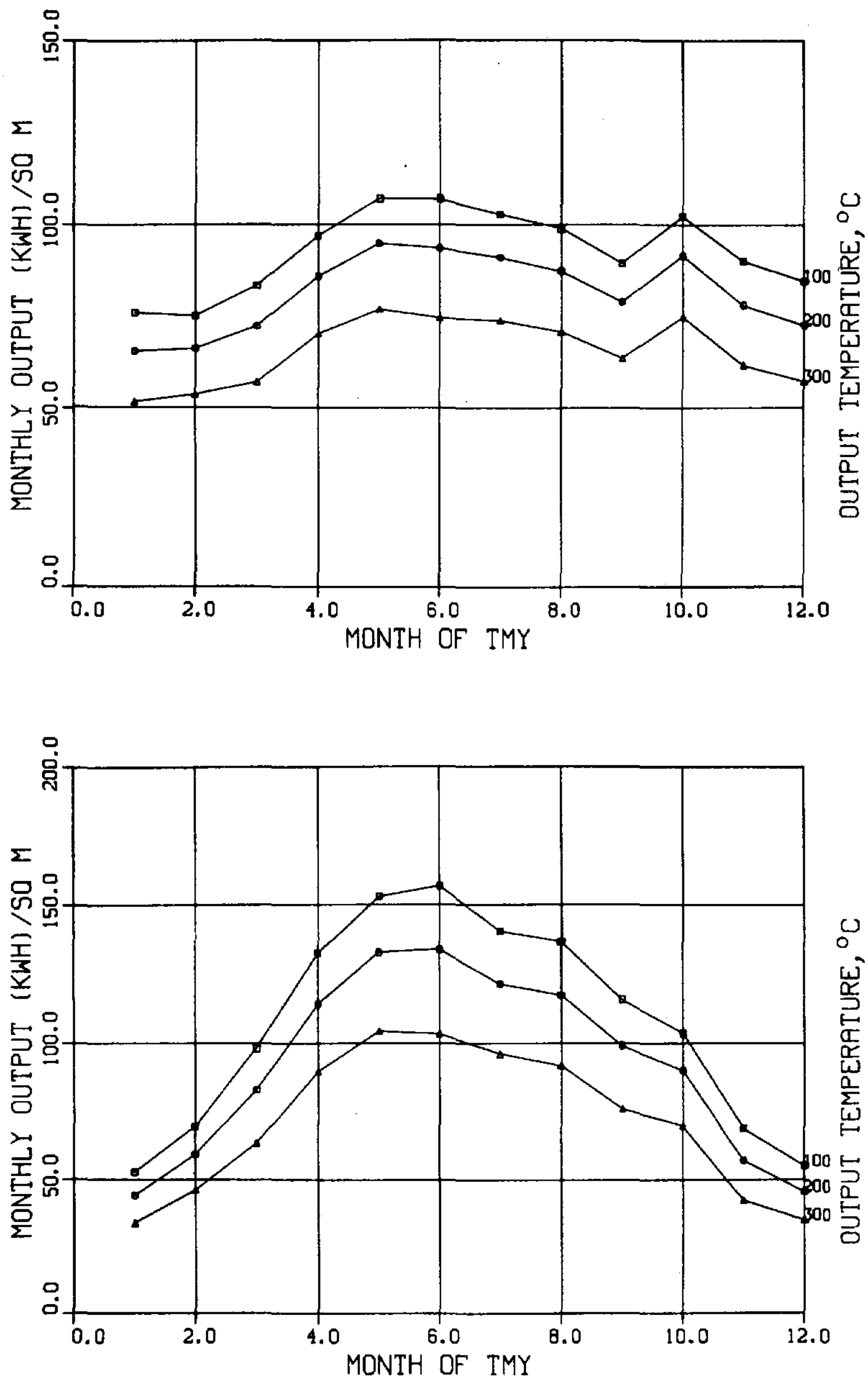

Figure 5. Thermal Output of the Acurex Solar Collector with FEK 244 Reflector Surface with E-W and N-S Orientation and Albuquerque TMY Solar Data

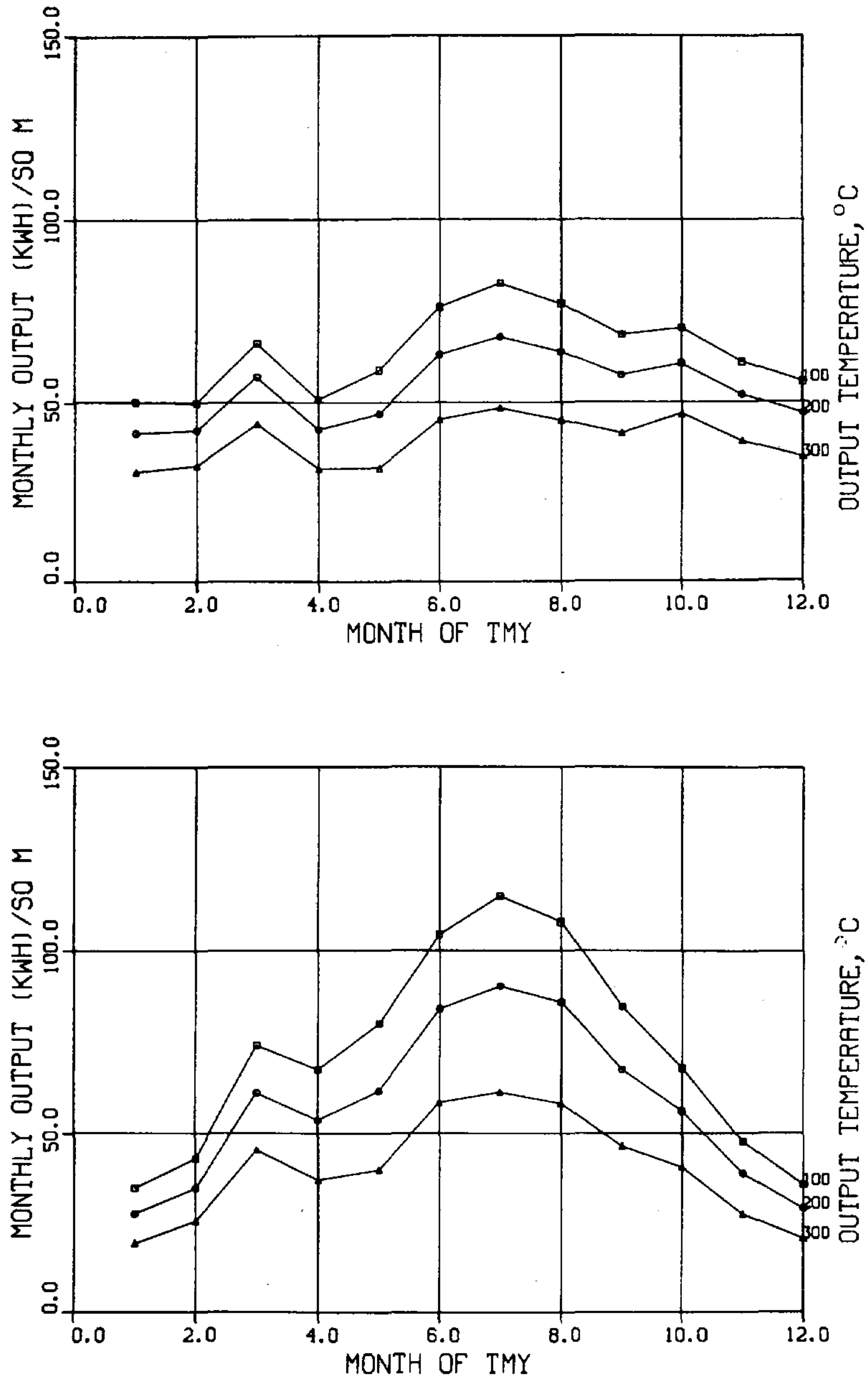

Figure 6. Thermal Output of the Acurex Solar Collector with FEK 244 Reflector Surface with E-W and N-S Orientation and Fort Worth TMY Solar Data

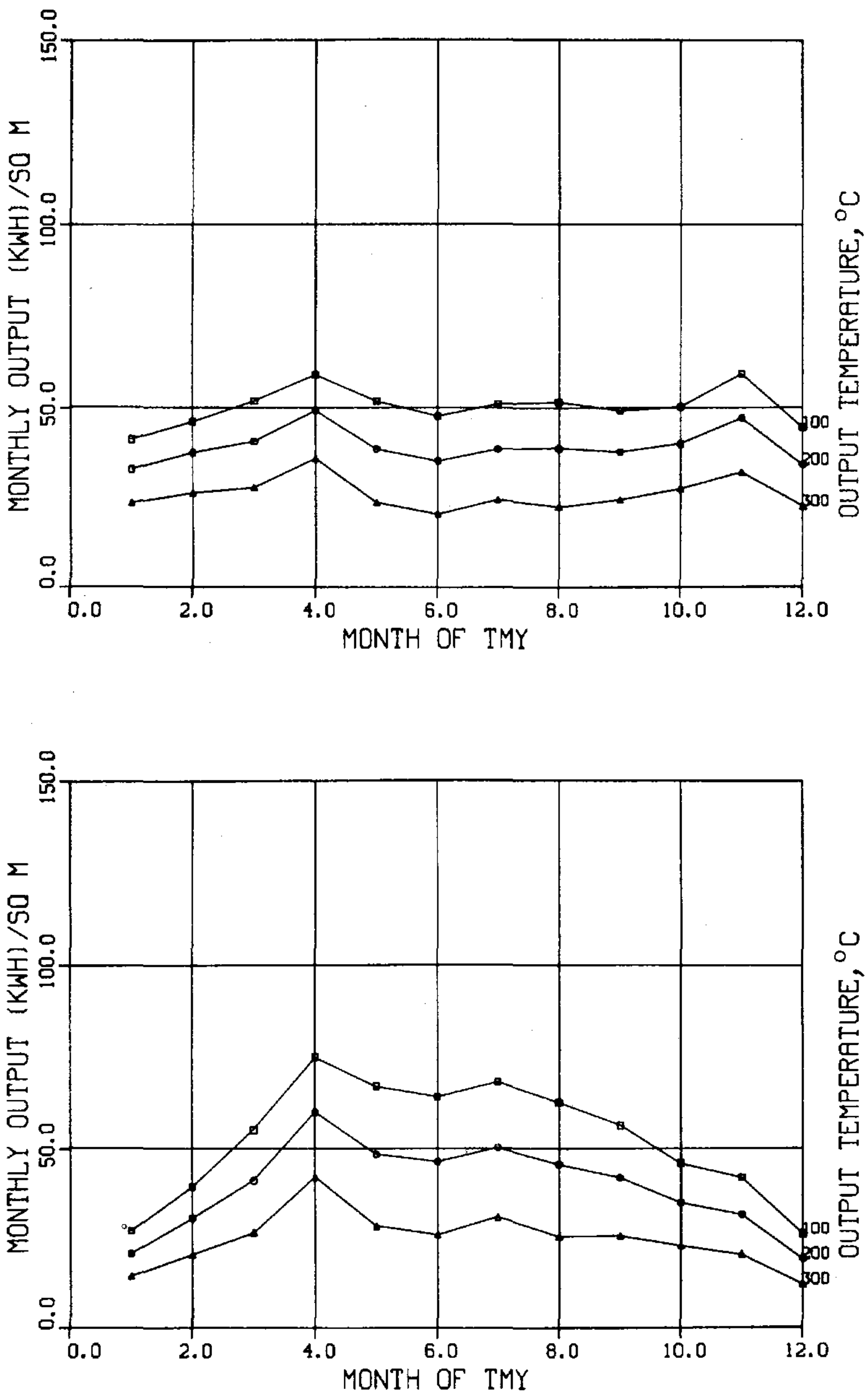

Figure 7. Thermal Output of the Acurex Solar Collector with FEK 244 Reflector Surface with E-W and N-S Orientation and Charleston TMY Solar Data

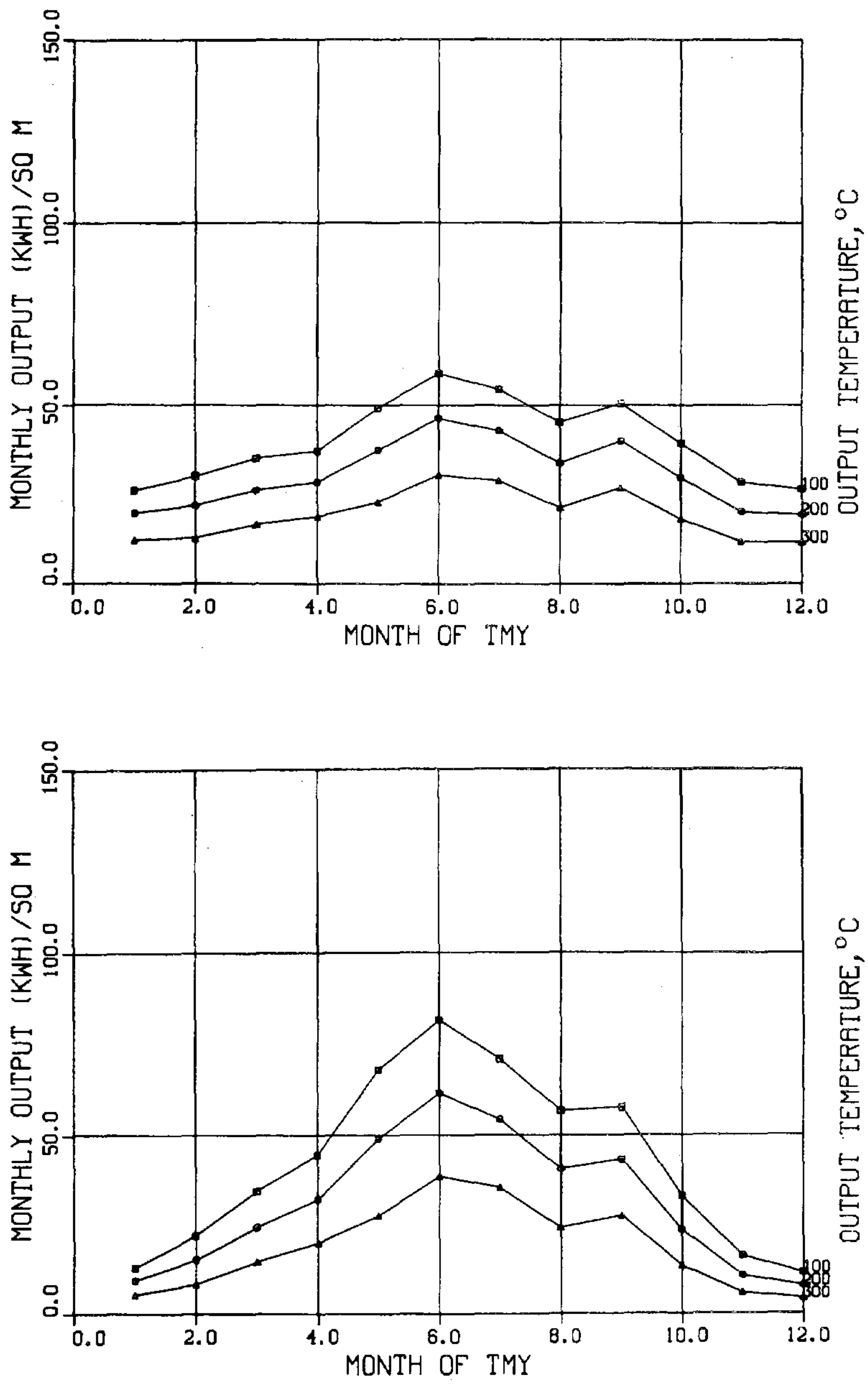

Figure 8. Thermal Output of the Acurex Solar Collector with FEK 244 Reflector Surface with E-W and N-S Orientation and Boston TMY Solar Data

Table 1

Predicted Annual Thermal Output ($kWh/m^2 \cdot yr$)

	Solar Energy Available	Output Temperature					
		100°C		200°C		300°C	
		Orientation		Orientation		Orientation	
		E-W	N-S	E-W	N-S	E-W	N-S
Fresno	2260	959	1154	824	962	635	713
Albuquerque	2583	1114	1283	978	1098	787	853
Fort Worth	1764	767	864	644	692	475	484
Charleston	1358	605	631	474	474	316	300
Boston	1173	484	512	371	375	237	228

Previously Published Predictions

Thomas D. Harrison, Midtemperature Solar Systems Test Facility Predictions for Thermal Performance of the Solar Kinetics T-700 Solar Collector with FEK 224 Reflector Surface, SAND80-1964/1 (Albuquerque: Sandia National Laboratories, November 1980).

Thomas D. Harrison, Midtemperature Solar Systems Test Facility Predictions for Thermal Performance of the Suntec Solar Collector with Heat-Formed Glass Reflector Surface, SAND80-1964/2 (Albuquerque: Sandia National Laboratories, November 1980).

Reference

[1] T. D. Harrison, Midtemperature Solar Systems Test Facility Program for Predicting Thermal Performance of Line-Focusing, Concentrating Solar Collectors, SAND80-1964 (Albuquerque: Sandia National Laboratories, November 1980).

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