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**COLORADO STATE UNIVERSITY PROGRAM FOR
DEVELOPING, TESTING, EVALUATING AND
OPTIMIZING
SOLAR HEATING AND COOLING SYSTEMS**

**PROJECT STATUS REPORT FOR THE MONTHS OF
OCTOBER AND NOVEMBER 1993**

Prepared for the

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Submitted by

**SOLAR ENERGY APPLICATIONS LABORATORY
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RATING AND CERTIFICATION OF DOMESTIC WATER HEATING SYSTEMS

Thermosyphon

The Micro-Motion flow meter for measuring the thermosyphon flow has been delivered. A tour of the Micro-Motion facility was taken to witness manufacturing and calibration procedures. The Eppley PSP pyranometer used for measuring radiation flux from the solar simulator was recalibrated at the factory. All equipment necessary for instrumentation has been received.

A prototype model of the proposed system for temperature measurement inside the storage tank (described in the previous progress report) was constructed and pressure tested. The experience gained during construction was valuable and should insure success of the final instrumentation.

ICS Off-Normal Testing

The integral storage collector system, which is still installed on the solar simulator test stand, was modified to allow off-normal testing. This modification involved removing one of the four tube banks to insure an acceptably uniform radiation flux from the solar simulator. It was not possible to correctly tune the simulator lamps when the entire eight-tube area was oriented off-normal.

Two tests were run to determine tau-alpha (normal); one at an angle of incidence (θ) of 28.8 degrees, and the other at an angle of incidence of 45.5 degrees. The corresponding tangential and longitudinal angles of incidence, along with the $(\tau\alpha)_n$ results are shown in the following table.

TEST 1

$\theta = 28.8^\circ$
 $\theta_t = 28.0^\circ$
 $\theta_l = 8.0^\circ$
 $(\tau\alpha)_n = 0.594$

TEST 2

$\theta = 45.5^\circ$
 $\theta_t = 42.7^\circ$
 $\theta_l = 23.1^\circ$
 $(\tau\alpha)_n = 0.559$

The result for a four tube ICS system using Arun Menon's ray tracing computer code is:

$$(\tau\alpha)_n = 0.599$$

In the first case the experimental result differs by 0.8% and in the second case, 6.7%. These are well within the experimental tolerances and, therefore, indicate validity of the ray trace method.

Tuning the simulator lamps for uniform irradiation was becoming difficult during test #2 and would preclude testing at larger angles of incidence.

UNIQUE SOLAR SYSTEM COMPONENTS

Integrated Tank/Heat Exchanger Modeling/ Experiments

The 80 gallon Rheem wrap-around heat exchanger tank has been installed in generic systems test stand in Solar House II. Extensive modifications to the control, instrumentation, and fluid supply systems are nearing completion.

- The cold water supply (supplies temperature conditioned water to the domestic water side of the hot water system for tank setup and make-up water during hot water draws) side of the fluid supply system is complete and has been pressure tested. Flow meters, thermocouples, and thermistors must be installed. The circulation pump is installed but not been tested.
- The hot water/collector loop is nearly complete. Modifications must still be made to remove the collector from the hot water loop to simplify operation. Flow meters, thermocouples, and thermistors must be installed. The circulation pump is installed but not been tested.
- The Keithly Metrabyte data acquisition cards previously used in the generic systems test stand have been exchanged for an Hewlett Packard System 10 data acquisition system from Solar House I. This exchange took two weeks, however, the HP System 10 provides higher resolution at lower noise levels for better measurement precision and accuracy.

Remaining tasks:

- Calibration and installation of the flow meters, watt transducers, and temperature probes (thermocouples and thermistors).
- Development and testing of new control algorithms for the cold water supply system and the hot water (collector) loop.

Test planning:

- During the period when the new control algorithms are being tested, a thermocouple tree will be installed in the 42 gallon auxiliary storage tank and the tank will be allowed to heat up overnight. Tank temperature profiles and auxiliary heater energy usage will be recorded. Detailed data acquired during these tests will be used to test the ability of the TRNSYS Type 4 storage tank model to accurately predict auxiliary tank performance.

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ADVANCED RESIDENTIAL SOLAR DOMESTIC HOT WATER (SDHW) SYSTEMS

This progress report is for the months of October and November.

A design has been completed for the installation of the weather station. The weather station includes two pyranometers (horizontal and 45° tilt), a vane anemometer with wind direction, and an ambient shielded thermocouple. The location is approximately in the middle of the test bed two meters off the ground. The necessary parts have been bought and installation will begin soon. A frequency-to-voltage converter will be needed to interface between the anemometer and the data acquisition system, this part will be built or a ready made one will be hunted down.

All of the thermocouples have been built. This process included making the thermocouple itself (soldered), then inserting it into a shield. The cap to the shield is filled with thermal paste then glued on with leak proof plumbers goop. The thermocouple is held in place with silicone that is inserted in the open end of the shield. The thermocouples have also been installed into the appropriate locations in the systems.

The flowmeters have been successfully calibrated. Several mechanical/electrical problems arose but they have all been fixed. The calibration was performed using an ASME venturi and a manometer. The venturi was calibrated and the manometer was seven feet tall to allow for greater accuracy in reading the pressure differences. The calibration curves are attached. The flowmeters will be installed soon.

ANALYSIS OF ADVANCED DESICCANT SOLAR COOLING SYSTEMS

The BLAST building model is near completion. We have defined control strategies, selected schedules for system operations and defined lighting and occupancy schedules. We have also selected conventional heating and cooling systems. This part of the work will provide the hourly sensible and latent loads of the whole building to the TRNSYS solar simulation. Also the BLAST model will provide the baseline energy use estimate for heating and cooling the building with conventional systems to compare in the future with the results of using solar energy.

From preliminary studies it has been realized that in most geographical areas, part of an office building will have cooling loads in the winter, due to occupancy and equipment use. Therefore, the solar system will need to operate all year, and might be used to provide heating as well as cooling to different parts of the building. This point is under investigation.

The description of the commercial office building being simulated is enclosed.

Figure 2.2 Building Floor Plan

Building Description
 * Total Area = 15,870 ft² = 1,475 m²
 32 outer offices 14' X 14' = 196 ft² = 18.21 m² each
 With 1 occupancy each.
 total area = 6272 ft² = 582.72 m²
 1 Core Zone 98' X 98' = 9,604 ft² = 892.24 m²
 housing 50 occupants.
 Ceiling is 8 ft high.

* Overall External wall average U = 0.526 Btu/hr.ft².R = 10.752 kJ/hr.m².K

Wall U = 0.048 Btu/hr.ft².R = 0.9812 kJ/hr.m².K

Glass U = 1.059 Btu/hr.ft².R = 21.647 kJ/hr.m².K

* Overall Roof U = 0.084 Btu/hr.ft².R = 1.717 kJ/hr.m².K

* Overall floor U = 0.076 Btu/hr.ft².R = 1.5535 kJ/hr.m².K

* Building overall average U = 0.106 Btu/hr.ft².R = 2.1667 kJ/hr.m².K

* The outer walls have a total of 47.3% of .5 in heat absorbing plate glass windows.

* Lighting Load = 2 W/ft² = 21.53 W/m².
 * Electric equipment Load = 1.5 W/ft² = 16.15 W/m².
 * Infiltration Rate = 0.75 Air Change/hr (when the fan is OFF)
 * Ventilation Rate = 18 cfm/person = 8 l/person.
 * Variable Air Volume System is selected.

MANAGEMENT AND COORDINATION OF COLORADO STATE/DOE PROGRAM

Coordination of research activities continued on the four technical research tasks under the DOE grant, and accounts were maintained and updated. Financial and technical reports were submitted as required.

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