Sandia Laboratories

Solar Energy

SOLAR THERMAL DISTRIBUTED RECEIVER TECHNOLOGY DEVELOPMENT AND APPLICATIONS PROJECT

TECHNICAL STATUS REPORT

APRIL-MAY, 1984

SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO
EDITED BY: E. C. BOES
J. A. LEONARD

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April/May 1984

HIGHLIGHTS

Distributed Receiver Technology Development

Significant progress has been made to date on the SO_3 lab-scale thermochemical transport loop constructed at NMSU. After eliminating a defective catalyst and overcoming some channeling problems with the packed catalyst bed, three successful short runs were conducted. A run of longer duration (5 hours) was conducted in late May Control of the exothermic temperature was found to operate smoothly.

Phase B of the site construction at the Distributed Receiver Test Facility (DRTF) is well underway. Phase B includes the foundations for the LaJet and Shenandoah collectors, the modifications to Building 9981 to create control room space, the circulating water system, electric power, and instrumentation cable trays.

Barber-Nichols completed the 200 hours of hot bench testing on their Organic Rankine Cycle (ORC) engine on April 3, under Sandia contract. After one and two-hundred hours of operation the ORC was dismantled for inspection of bearings and internal conditions. Except for normal glazing of the bearings, all remaining rotating surfaces appeared as their original installed condition. These results indicate that the material bonding problems which plagued the bearing shoes were solved.

Distributed Receiver Evaluation

The first evaluation test of the Shenandoah Test Operation Phase was performed on April 5, 1984. This test was the first in a matrix of twenty-nine prime experiments designed to determine the capabilities of the Shenandoah Solar Total Energy System.

The solar IPH system at USS Chemicals Co. is operating routinely. Steam production is running at 8,000 lb/h with good insolation. The solar energy system utilization factor was 100 percent. Neither the solar energy system nor the USS Chemicals plant were down anytime during the month of April.

The optical efficiencies of the BDM MISR collectors were measured. Results were as follows: ECP-300X, 78%; FEK-244 69%; and glass, 77%. All measurements were made using Pyrex receiver glazings without anti-reflective treatment. The measured reflectivities are: ECP-300X, 97%; FEK-244, 84%, and glass 95%.

Solar Concentrator Technology Development

Optical properties of a matrix of silver coated mirror polished stainless steel coupons were measured before and after coating the coupons with protective glass by the sol-gel process. Specular reflectances of just over 0.9 are being measured for the better samples.

The proposals received in response to SNLL's RFP on a stressed membrane heliostat were reviewed and ranked so that negotiations could begin on placement of this contract.

PUBLICATIONS

J. V. Fox, Fox Consulting Sevice Co., "Thermochemical Energy Transport Systems Study," SAND83-7464, March 1984.

J. A. Leonard, C. R. Klimas, Eds., "A Bibliography of Reports of the Sandia Solar Thermal Distributed Receiver Systems Project," SAND84-0313, April 1984.

PRESENTATIONS

R. L. Champion, "Heliostat Development Program Overview," Solar Central Receiver Annual Meeting, San Diego, CA, April 24-26, 1984.

CONTRACT MANAGEMENT SUMMARY REPORT

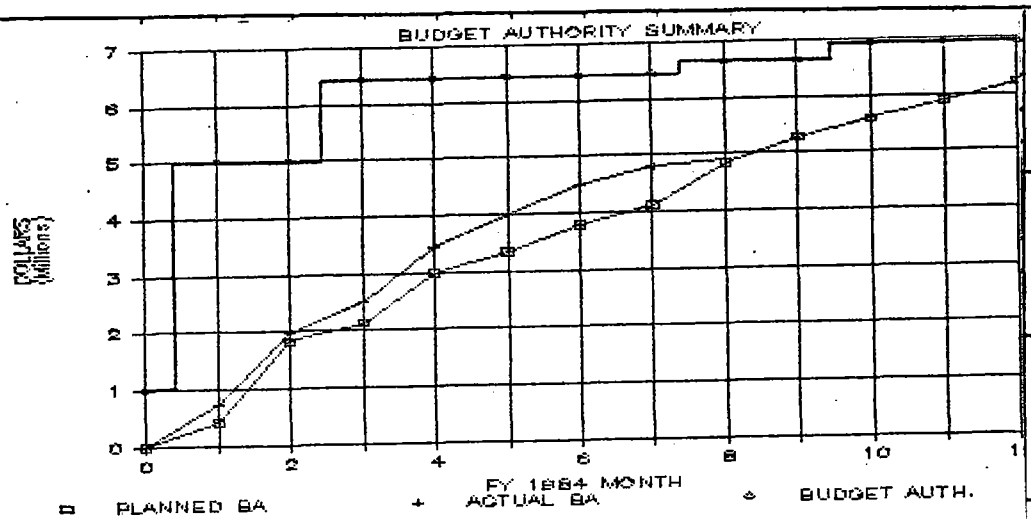
1. Contract Identification	2. Reporting Period	3. Contract Number
Distributed Receiver Technology and Applications Project	4/1 through 5/31	0650 & 0903

4. Contractor (name and address)	5. Contract Start Date	6. Contract Completion Date
Sandia National Laboratories, Div. 6227 Box 5800 Albuquerque, NM 87185	10/83	Continuing

7. Months													8. FY

9.

a.



e. Actual Costs Prior FYs: NA

f. Planned Costs Prior FYs: NA

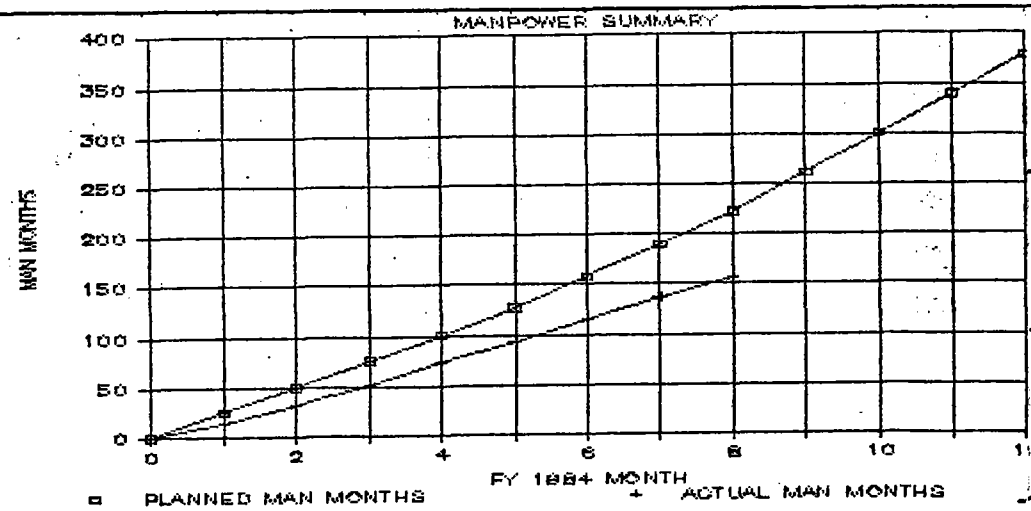
g. Total Estimated Accrued Costs for Contract: NA

h. Total Contract Value

Accrued Costs		OCT	NOV	DEC	NOV	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	b. Planned	412	1413	308	848	347	453	323	724	429	324	323	326
	c. Actual	182	270	348	378	748	451	583	366	0	0	0	0
	d. Variance	-230	-1143	-40	470	401	-2	260	-358	-429	-324	-323	-326

10. Manpower Status

a.



e. Actual Manpower Prior FYs: NA

f. Planned Manpower Prior FYs: NA

g. Total Estimated Manpower for Contract: Continuing

h. Total Contract Manpower

Manpower		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	b. Planned	25	25	25	25	27	31	32	32	39	39	39	39
	c. Actual	15	17	20	21	20	22	22	21	0	0	0	0
	d. Variance	-10	-8	-6	-4	-7	-9	-10	-11	-39	-39	-39	-39

11. Remarks

12. Signature James A Leonard

Number:	4
Date:	June, 1984
Period:	04/1/84 - 5/31/84
B & R Code:	EB-02-01
Project:	Distributed Receiver Technology Development and Applications Project
Title:	Project Management (AOP Task 1)
Contractor:	Sandia National Laboratories, Albuquerque, New Mexico 87185

ACOMPLISHMENTS

1.0 Project management - Resources will be budgeted to meet the work plan outlined in the AOP. Activities required to meet the project objectives will be identified and progress toward these objectives will be monitored. Budget allocations, manpower needs and milestone monitoring will be administered. Liaison with appropriate DOE offices, laboratories, and other agencies will be maintained to assure that a well integrated, balanced Distributed Receiver Project is conducted.

1.1 Project Report

The Solar Thermal Semiannual Program Review was held in Rockville, MD, May 23 and 24. Distributed Receiver technology was represented with presentations from Acurex, Advanco, LaJet, Luz, 3M, and Eldon Boes, Jim Leonard, and John Otts of SNLA. A recommendation has been made to DOE/HQ by SNLA that future Semiannual Reviews be combined with Quarterly Reviews by holding a closed meeting for program review, budgetary, and other sensitive presentations on the first day of a three-day meeting and then inviting industrial and other participation on the second and third days. A favorable HQ response would result in substantial savings in travel costs and preparation time.

Informal FY85 AOP planning meetings for the Distributed Receiver Program were held among representatives of DOE/HQ, DOE/AL, SNLA, and JPL on April 17 and 18, and May 9. Good progress was made in mutual communication of the range of activities which would be of interest, and the ordering of priorities of these activities.

Inputs to DOE's Five-Year Plan were submitted, the first draft of the plan reviewed, and comments were furnished to the TPI.

A SERI-prepared document which provided a Solar Thermal Program overview and annotated bibliography was reviewed and comments were furnished to SERI.

A SERI-prepared Solar Thermal summary which is to be submitted to Rand-McNally for a technical encyclopedia was reviewed, and comments were furnished to SERI.

A meeting of the Solar Thermal Division of the SEIA on April 11 was attended by a representative of SNLA. The meeting was hosted by SERI, and it provided a good vehicle for communication between SEIA and the elements of the Solar Thermal program - particularly the research program.

Bob Casanova of Georgia Tech visited SNLA on May 16 and discussed topics of mutual interest with the Distributed Receiver project and materials people. High temperature materials and coatings were the primary subject.

1.2 Project Planning

TECHNICAL APPROACH OR WORK PLAN CHANGES

None

VARIANCES

None

OPEN ITEMS
None

FORECAST FOR NEXT REPORTING PERIOD

A draft AOP which is coordinated between ALO and SNLA will be submitted to DOE/HQ by June 22.

Number: 4
Date: June, 1984

Period: 04/1/84 - 5/31/84

B & R Code: EB-02-01

Project: Distributed Receiver Technology Development and Applications Project

Title: Distributed Receiver Technology Development (AOP Task 2)

Contractor: Sandia National Laboratories, Albuquerque, New Mexico 87185

Accomplishments

2.0 DISTRIBUTED RECEIVER TECHNOLOGY DEVELOPMENT - The parabolic dish potentially has the highest energy collection capability of any distributed receiver system. The high concentration ratio reduces receiver area and thermal losses and two-axis tracking eliminates the cosine effect losses and provides a constant all day efficiency. This task seeks in the long term to provide a parabolic dish solar thermal capability in excess of 1200°C for applications such as industrial process heat, including fuels and chemicals production, electrical power, and cogeneration.

2.1 Systems Engineering and Analysis

A study investigating the effect of terminal concentrators in parabolic dish performance was concluded. The code COPS (Concentrator Optical Performance Software), using a ray trace technique, indicated the advantages of the terminal concentrator in conditions of shallow rim angle, high concentration ratio, or high primary dish surface slope errors.

A follow-up analysis of a JPL study by Moynihan on second-law efficiency of solar-thermal cavity receivers has been conducted to determine the effect of dish slope error. Preliminary results indicate that the virtual image of the sun reduces in temperature from 5800K to 3800K in one reflection of a 94% mirror and a good quality dish. It reduces to 3100K if the slope error changes from 3 milliradians to 8 milliradians. The results indicate that high concentration dishes are desired and should be obtained with a minimum number of reflections.

2.2 Energy Transport and Development

SO3 Dissociation Experiment

Significant progress has been made to date on the SO_3 lab-scale thermochemical transport loop constructed at NMSU. After eliminating a defective catalyst and overcoming some channeling problems with the packed catalyst bed, three successful short runs were conducted. A fourth run was conducted while Sandia personnel were present. A run of longer duration (5 hours) was conducted in late May with the exothermic reactor temperature being controlled solely by varying the flow rate within the loop or by increasing the ventilation of the exothermic furnace. In both instances the control of the temperature was found to operate smoothly.

Some ideas along the lines of achieving reactor temperature control in a multi-reactor experiment were discussed with Jim McCrary, as well as methods for obtaining experimental measurements of the energy output of the exothermic reactor in order to calculate actual efficiencies. The possibility of operating the SO_3 system using liquid SO_3 and achieving central control of various reactors was discussed for possible future experiments. Using a liquid to establish central control would cut down on the piping size as well as individual controls for each dish reactor. Such a system is claimed to be operating efficiently for the NH_3 system in Australia.

CLEA Experiment

Activities on the Closed Loop Efficiency Analysis (CLEA) experiment, a laboratory study of the $CH_4 + CO_2$ thermochemical transport system, included procurement and installation of experimental components. The endothermic and exothermic reactors were designed and are being fabricated. The gas chromatograph was received and installed, and two catalysts were received - nickel on alumina and ruthenium on stainless steel (J. D. Fish, Process Research Division).

TC-Transport Literature Survey

The report on the literature survey for TC transport in a solar application has been completed. In essence, the concept is technically feasible and the opinions on economic viability vary from optimistic to pessimistic. The most comprehensive report, authored by Flock and Vakil, arrives at an incremental cost for TC transport of solar energy of \$3.09 GJ (\$.01/kWh).
Some of the higher cost estimates can be attributed to the unknowns in TC technology which, in our opinion, have been assigned unduly high costs.

The materials testing in support of TC transport has thus far shown Inconel and SS316 to be suitable for heat exchanger materials. Reactor and pipeline temperature experiments have yet to be conducted.

Economic Analysis of Sensible and Thermochemical Thermal Energy Transport Systems

A parametric systems analysis has been initiated to compare the performance and costs of sensible (SEN) and thermochemical (TC) thermal energy transport from a field of parabolic dish collectors to a nearby user. The comparison is being made on the basis of user needs (i.e., output energy Q_o, and temperature, T_o) and system costs. The system size and temperature ranges under consideration are : Q_o = 1 to 1000 MW_t and T_o = 300° to 815°C. The objective of the study is to identify those regions in the Q_o-T_o parameter space where thermochemical transport is more economical than sensible, and vice versa, and why.

Preliminary performance estimates for SEN and TC transport systems based on the Shenandoah collector layout have been obtained in a companion study: "Piping Heat Loss Study for Dish Solar Collector Fields," J. M. Diggs, 6227. A rudimentary computer model was developed that selects the optimum diameter and insulation thickness for each pipe segment in the network, based on minimizing energy losses and pumping power, and computes overall losses and transport system efficiency (M. Larson and R. Akau of the Fluid Mechanics and Heat Transfer Division). These calculations have been performed for three working fluids, two sensible (steam, sodium) and one thermochemical (SO_3/SO_2+O_2); two system sizes, 4.4 and 44 MW_t, and four operating temperatures (at the receiver outlet), approximately 400, 540, 675, and 815°C. The performance results are currently being evaluated and efforts to estimate the costs of the various systems have been initiated (J. Diggs, E. Rush, S. Kuritz, Distributed Receiver Systems Division.)

A more realistic approach for the present thermal transport systems economic analysis is to optimize the piping network based on costs (capital and operating) as well as performance. The ETRANS code developed at PNL is a performance/cost optimization model for sensible transport piping systems for distributed solar collector fields. A tape copy of this code was obtained during the report period and brought up and run on the SNLA UNIVAC computer by J. Prue of the Computer Consulting and Training Division.. Subsequent efforts have concentrated on familiarization with the code, setting up an input file for a sample problem, transporting the code to the Area V VAX (G. Buck, Distributed Receiver Systems Division) and coordinating with PNL to have them run the same sample problem using their ETRANS code.

2.3 Receiver Development

SNLA Evacuated Annulus Receiver

The fabrication process for SNLA evacuated annulus receivers is about 50% complete and progressing slowly because of competing demands by other projects. The new high capacity vacuum pump which was received with the wrong type flange has been exchanged and is presently being installed.

Acurex Evacuated Annulus Receiver

Acurex's original butt joint design for brazing inconel bellows to ceramic failed by cracking the ceramic upon cooling from the brazing temperature. Three alternate designs were tried with the following results.

1. They successfully made brazed closures with intermediate copper rings between the Inconel and ceramic. This adds a series seal to a string which already included two or three grades of glass-to-ceramic-to-inconel. The fatigue strength of copper is also a concern.

2. They thinned and annealed the Inconel ring to limit the force it can transmit to the braze joint, thus lowering stress in the ceramic. Two out of five broke, and the remaining three showed evidence of cracking.

3. Larson Electronics of Redwood City, CA, made two successful knife edge or "housekeeper" seals of inconel directly to Pyrex glass. The exciting prospect for this alternate, if it survives thermal cycling and other tests, is the elimination of all intermediate graded seals between the Pyrex glazing and the Inconel bellows. It is known that seals of this type using stainless steel bellows have failed due to intergranular corrosion of the stainless steel. Inconel is not expected to have this problem.

2.5 Distributed Receiver Test Facilities

Phase B of the site construction at the Distributed Receiver Test Facility (DRTF) is well underway. Phase B includes the foundations for the LaJet and Shenandoah collectors, the modifications to Building 9981 to create control room space, the circulating water system, electric power, and instrumentation cable trays.

2.5 Distributed Receiver Test Facilities(continued)

The transfer of equipment from the PDTS to the DRTF was essentially completed. The second test bed concentrator, TBC-2, and the GE low cost parabolic dish concentrator, PDC-1, were disassembled and shipped to the DRTF. A few items remain to be shipped from the PDTS because they were inadvertently left off the shipping paperwork prepared by JPL or were not included in the inventory of DOE-purchased equipment at the PDTS. In addition, there are other items at other JPL sites, such as the main laboratory in Pasadena, that have not yet been shipped or inventoried. Transfer of equipment from the PDTS to the DRTF was suspended for a week during the reporting period to allow JPL to complete optical characterization of PDC-1. During this time, Sandia personnel oversaw the move of the rotating platform and associated fluid loops from the Collector Module Test Facility to the DRTF.

Two representatives of the Solar Thermal Test Facility Division visited JPL to discuss preparations to optically align TBC-1; JPL personnel will be on-site during June to train Sandia personnel in this activity.

2.6 Engine Development for Dish-Electric

ORC

Barber-Nichols completed the 200 hours of hot bench testing on their Organic Rankine Cycle (ORC) engine on April 3, under Sandia contract. After one and two-hundred hours of operation the ORC was dismantled for inspection of bearings and internal conditions. Except for normal glazing of the bearings, all remaining rotating surfaces appeared as their original installed condition. These results indicate that the material bonding problems which plagued the bearing shoes were solved. Completion of this test indicates the ORC Engine shows promise as a candidate for near term dish-electric installation. An automatic control system will be added to the engine for its installation on the TBC-1. This should take place approximately September 1984.

SABC

Final contract negotiations were conducted with Sanders Associates on March 27-28, 1984. H. Holbeck, JPL, participated in the negotiations. Sanders' overhead has been reduced and the savings applied to developing an extra control module and an electric starter for the system to be tested at Sandia. In turn, Sandia will fabricate the structural members needed to strengthen the LaJet dish and will assemble the dish. This negotiation will allow the dish module at Sanders to remain in operating condition while the second module is being tested at Sandia. Sanders has completed enough receiver

tests to learn that a design modification was necessary. The ceramic receiver was moved two inches further from the aperture to obtain more uniform distribution. Testing is to resume April 9, 1984. Sanders Associates received new replacement mirrors from LaJet on April 11 to replace several that contained wrinkles. This brought the captured flux to 21 kW from 15 kW. An AiResearch representative visited Sanders on April 16 to install the alternator on the turbine shaft. The module controls are complete and the engine has been moved next to the dish so that the controls can be operated before the engine is installed on the dish.

On April 26 and 27, the Brayton Cycle Engine was operated on the ground at Sanders Associates by burning natural gas. The purpose was to check out the controls and they operated satisfactorily. The flux rake was determined to operate satisfactorily also. This means that energy into the receiver can be determined when the dish operation begins. Further on-ground testing was delayed because of problems with the convertor feedback signal and engine control, but these were solved, and the engine was dish mounted on May 14. The engine operated at 1600°F TIT, and 700 rpm. Flux rake tests at the aperture of the receiver indicated 21kW_t collected compared to a design level of 27 kW_t. Sanders reported on May 29 that the Brayton Cycle Engine was mounted on the collector and after a few more connections, operation could begin. Late Note: First power on sun was produced on June 7.

An agreement has been reached on the material invoice between JPL and Sanders, only some signatures are needed to make it official. Sandia has initiated a contract change to incorporate this material into the Sandia/Sanders contract.

AiResearch has conducted a design study for Sanders which indicated the 8 kW alternator could produce 18 kW with active cooling. This capability would be necessary if the engine were to be modified to a pressurized Brayton cycle.

Direct Conversion Devices

Ford Motor Company, General Electric and JPL were identified as agencies or companies doing R & D on Alkali Metal Thermo-Electric Converters (AMTEC) or Sodium Heat Engines (SHE), which are a subset of AMTEC. We visited Ford Motor Company for an in-depth discussion of the SHE with Dr. T. K. Hunt who heads a group of three researchers and supporting people at Ford. Ford patented the SHE in 1968 and has had a small R & D effort on that device for about 20 years. They currently have two contracts with funding from

DOE's Office of Industrial Programs; one for basic research on electrode materials, and one to build a 200 W device by the end of FY85. Ford's research has been basic and not tied to any specific application. Through a phone call we learned that GE had done internally funded R & D on the SHE for possible space power applications. That effort was a casualty of recent cuts in internal research funding. GE had built four SHE units, three of which performed well. They believed that the alumina broke during fabrication on the unit that didn't work.

Dr. Terry Cole of JPL visited Sandia to discuss AMTEC devices and JPL's basic research on electrode materials for those devices. Their interest is also for space power applications. The SHE appears to offer potential for both solar and space power applications. There seems to be a consensus that electrode material problems are slowly yielding to research. The remaining effort required is mainly engineering.

Magnetic Heat Pump

The Magnetic Heat Pump Program at Idaho National Engineering Laboratory was reviewed by a Sandia representative on May 14-15. This technology could be applied to a magnetic heat engine concept. The engine would have characteristics of low rpm, high torque, few moving parts, and shows promise of 80% Carnot efficiencies. Applying this technology to a solar use is being considered for near and long term use.

Sol-Gel Coatings

Sandia is currently conducting research on thin-film glass, or "sol-gel" for various solar and non-solar applications.. Sol-gel is being considered for use as an antireflective coating for windowed cavity receivers. This coating would provide for low window reflectance (1 to 2%) for the solar spectrum (300 nm to 1200 nm), thus allowing more energy into the receiver. Sandia is experimenting with various sol-gel solutions to determine a combination which will survive the high temperature cavities. To date, sol-gel has maintained its properties in a 750^{o}C environment. More work will be required to increase this temperature limit. The application currently under consideration if for the Sanders/Brayton receiver.

Stirling

A review of an Operational Test Plan proposed by EPRI was held on April 27 in Palm Springs, CA. The meeting concerned the Vanguard Solar Parabolic Dish-Stirling Engine Project. A preliminary draft of the plan was discussed with inputs from Advanco Corp., JPL, SNLA, Utility Advisory Group, and EPRI. Sandia will serve as technical advisor as outlined in the FY84 AOP for distributed receivers. Testing will begin in May and continue through September.

TECHNICAL APPROACH OR WORK PLAN CHANGES

None

Variances
None

Open Items

None

FORECAST FOR NEXT REPORTING PERIOD

2.2 Energy Transport and Development

The SO_3 loop will be operated with durations of up to eight hours. Attempts at obtaining energy conversion efficiencies will be made. Variations on the length of the pipeline will be studied for any effect on the measurable parameters. A log will be made for several days of all difficulties in starting up the system each morning.

The parametric systems analysis comparing the performance and costs of sensible and thermochemical thermal energy transport from a field of parabolic dishes will continue. Emphasis will be placed on: completing development of the necessary computer model(s) to perform the systems cost/performance calculations (including evaluation and modification of ETRANS), making performance calculations and cost estimates for the complete set of Q_o and T_o selected, and conducting parametric analyses. The code developed to predict performance of pipe designs will be enhanced to include and optimize on a cost basis.

The CLEA experimental thermochemical transport loop will be installed and preliminary thermal analysis and catalytic activity studies should be completed.

2.3 Receiver Development

SNLA evacuated annulus receivers will be assembled and deployed for test on a Custom Engineering MISR drive group (six receivers plus spares) and testing begun. Additional receivers will be assembled for accelerated mechanical life tests and for experiment with an integral vacuum indicator.

Acurex will have additional Inconel-to-Pyrex seals made upon receipt of additional Inconel bellows, which are ordered. When they think they have a good candidate design they will deliver the test devices under contract 52-9909.

2.5 DRTF

Phase B construction of the DRTF will be completed. Emphasis will be placed upon completing the transfer of knowledge of the test equipment and techniques from JPL to Sandia. Included in his activity will be the alignment of TBC-1.

PROBLEM AREAS

None

Number:	4
Date:	June, 1984
Period:	04/1/84 - 5/31/84
B & R Code:	EB-02-01
Project:	Distributed Receiver Technology Development and Applications Project
Title:	Distributed Receiver Evaluation and Technology Transfer (AOP Task 3)
Contractor:	Sandia National Laboratories, Albuquerque, New Mexico 87185

ACCOMPLISHMENTS

3.0 DISTRIBUTED RECEIVER EVALUATION AND TECHNOLOGY TRANSFER - This activity includes the technical management support and long term evaluation of existing field projects including the Shenandoah Solar Total Energy Project (STEP) and the Industrial Process Heat Projects; the completion of the MISR project and its follow-on system improvement developments; the Small Community Solar Experiments; the continued evaluation of privately-developed line-focus hardware in high-risk, high-payoff areas of technology, and the availability of a cadre of knowledgable personnel in line-focus technology to provide continuing technical advisory support to private sector developers.

3.1 Shenandoah Evaluation

The first evaluation test of the Shenandoah Test Operation Phase was performed on April 5, 1984. This test was the first in a matrix of twenty-nine prime experiments designed to determine the capabilities of the Shenandoah Solar Total Energy System. The tests are as specified in the work statement of Amendment 12 of the U. S. DOE/Georgia Power Company Cooperative Agreement No. DE/FCD4-77ET20216, a cost sharing arrangement, with this phase costing Georgia Power $300K and the DOE $200K.

A total of six evaluation tests were performed by Georgia Power Company during the April-May time period. Tests reports have been written and data tapes submitted for the first three tests (see Variances), and the others are in process. Two of the six tests were cogeneration (electrical and process steam/air conditioning outputs) while four were electrical generation only. All used the fossil fired heater for energy input. Some system operating problems have been resolved but others remain to be solved or corrected.

An effort is being made by Georgia Power to improve the temperature regulation of the Syltherm HTF from the field. When the HTF temperature from a branch exceeds 700°F (normal operation 725 to 750°F) a high probability exists that one or more collectors in a branch exceeds the maximum allowable temperature (770°F). The computer is being reprogrammed to decrease the overtemp probability and to also decrease the amount of hand valve flow adjustment required by persons in the field. Consequently, the testing that involves solar energy input has been delayed while the computer programming is being completed.

A heat balance problem with the steam generator was recently investigated where incorrect flow measurements were believed to be the cause of calculated efficiencies slightly greater than 100%. The investigation showed that when the flow measurements were correct, the correct efficiency should be 97-98%, and that the temperature measurements were in error due to improper calibration and due to the use of a stem sensitive RTD instead of a tip sensitive one.

Other problems involving the electrical generator and auxiliary power supply were resolved by precision electrical phase measurements, replacement of two current transformers, and changing the direction of phase rotation of the auxiliary power supply.

A team has been assembled to analyze the data being generated by the Shenandoah evaluation tests. SERI will do a theoretical performance analysis for the system and the major components of the system. Bill Stine of California Polytechnic will perform an energy cascade analysis of the Shenandoah system. Sandia's Data Systems Department will provide for the transfer of data from the Georgia Power Company tapes to the computer systems used at SERI and Cal Poly. A meeting was held at Shenandoah on April 27, 1984 where representatives from these groups met to discuss their various requirements.

A spare parts list was prepared by Georgia Power Company personnel at Sandia's request where the items were listed by priority according to need. The list included items of instrumentation not currently on hand but required for testing or calibration of other instruments. The list also included spare parts for one-of-a-kind components to avoid excessive shutdown time while waiting for procurement. The total cost of the items on the list was approximately $50K. Arrangements were made for the transfer of this money by DOE/PR to Georgia Power. Having these spare parts on hand should significantly expedite the completion of the Shenandoah test program.

3.2 Industrial Process heat

See attached report.

3.3 Modular Industrial Solar Retrofit (MISR)

Acurex

A flexible hose has failed on the Acurex system after 4700 cycles. This is the first failure of a hose on this system. The hoses are 3 inch diameter hoses with strip wound covers. In previous testing in a flex hose tester at Sandia, similar hoses failed after 3000 to 3500 cycles. The failed hose has been replaced with one of the hoses which was removed when the rotary joints were installed. After it was replaced, it was found that the receiver was rotating freely, which allowed the flex hose end to rotate out of its usual alingment relative to the collector. If this had happened before the failure, it is possible that it was the cause of failure since the hose could have been stressed in certain configurations that might result from the rotation of the receiver. The receiver is normally prevented from rotating by a small clamp at the center of the drive group. We have been unable to tighten this clamp sufficiently to prevent rotation, so the clamp may have to be modified.

An all-day run was performed at near atmospheric steam pressure. The measured system efficiency compares favorably with calculations based upon earlier measurements of efficiency at normal incidence. thermal loss, and incident angle modifier from near ambient temperature runs. Some asymmetry in the system performance about solar noon was observed and is believed to result from inaccuracies in the tracking system. All-day runs will also be made at higher temperatures.

BDM

Optical efficiency measurements on the T-700 collectors in the BDM system have been completed. Four of the drive groups have reflective surfaces of FEK-244, an aluminized acrylic. One has ECP-300X, a silvered acrylic, and the other has thin-glass steel laminate mirrors. The performance of the collectors was measured with water as a heat transfer fluid so that the collectors were operating at approximately ambient temperature, yielding optical efficiency.

The optical efficiencies of the collectors were: ECP-300X, 78%; FEK-244 69%; and glass, 77%. All measurements were made using Pyrex receiver glazings without anti-reflective treatment. The measured reflectivities are: ECP-300X, 97%; FEK-244, 84%, and glass 95%.

Several months ago, the measured efficiency of the FEK-244 mirrors was about 74%, which is consistent with module tests performed on the rotating platform at the CMTF in 1981. A module equipped with glass reflective surfaces was also tested on rotating platform and was determined to have an optical efficiency of 78%. The reflectivity of the FEK-244 reflective film in the BDM system has not changed and all instrumentation

has been checked. A receiver was removed for measurement of the black chrome absorptivity, and the measured result was 95.3%, which is very good. The cause of the change in performance is still under investigation; none of the other systems have been observed to change.

Before the optical efficiency tests were performed, Solar Kinetics replaced three cracked mirrors in the BDM system. Two had cracks prior to installation; the other was accidentally damaged during installation. In addition, there are some visible deformities in the glass, possible due to lamination defects. These will be evaluated with the portable laser ray trace unit. A T-700 module which has an ECP-300X (silver film) reflective surface was laser ray traced and was found to have an rms slope error of 4.7 mr.

Following the optical efficiency tests, the system was filled with Caloria. A pressure relief valve was then replaced after it began to leak. This valve is designed to relieve excess pressure in the heat transfer fluid piping. It appears that the pressure setting of the original valve may have been a little too low. Four leaks at receiver joints also required repair. Two of these leaks were in joints that had recently been assembled; two were in joints that had not been observed to leak previously. The system now is fully operational for the first time in several months.

The limit switches on the T-700 collectors have failed intermittently in a manner such that the collector will not drive towards the stow position. The new drive group which has glass mirrors has magnetic reed switches. SKI has a retrofit kit available with these types of switches.

CEI

The CEI QTS has not been operated in the solar mode for most of the reporting period because of problems with the standby electric generator. Replacement parts have been ordered. We continue to life cycle the system. The local controller which was installed by CEI as an upgrade on drive group 4 has failed again. The other controllers have also occasionally shown intermittent failures to track.

Foster Wheeler

Installation drawings have been received from Foster Wheeler for the new rotary joints, and a representative of Foster Wheeler has visited the SERI MISR test site to arrange for a contractor to install them. The rotary joints have been delivered to the site.

Solar Kinetics

Optical efficiency measurements have been performed on the drive group which had been modified by the addition of two collector modules to complete a 160 ft. drive group. Cold water ws used as a heat transfer fluid for these measurements. The efficiency of this group appeared to be about six percentage points worse than the 120 ft. group. it was evident by inspection that there was some twist in the collector row which was causing light to miss the receiver at the west end. The tracker head was adjusted to minimize the amount of light which missed the receivers due to the slight twist, and efficiency comparable to the 120 ft. group was then obtained.

A valve has been installed in the balance of field simulator piping to allow operation of the SKI delta-temperature collector string using heat transfer fluid from the CEI skid while the SKI skid continues to be on loan for a commercial IPH project in Yuma, Arizona. This change has no effect on the operation of the CEI collectors. Performance tests at operating temperatures are currently underway on the 160 ft. drive group.

3.4 Dish Electric Field Experiment Support - Two Small Community Solar Experiments (SCSE's) are planned for evaluation of solar electric 100 kWe plants in a small community environment. The DOE has selected Osage City, Kansas and Molokai Island, Hawaii as sites for these experiments. Each SCSE will use point-focus concentrators and heat engines. New development of components and subsystems is not envisioned as part of the SCSE's. A competitive solicitation for proposals was issued by the DOE/AL in FY1984. SNLA will provide technical and management support to DOE/AL for these projects.

Osage City, Kansas - A meeting was held with representatives of Osage City to discuss and to define the technical work scope for the project in the prior report period. The work scope was defined and provided to DOE and to Osage City for the preparation of costs to be submitted to the DOE. Several calls have been received from an Omaha A and E firm requesting clarification of the project scope and intent. This firm is performing the cost estimating for Osage city. A SNLA contract was let to provide topographical data, survey, and subsurface exploration of the site. This work has been completed and final drawings and reports have been received.

Molokai Island, Hawaii - Insolation data based on available measurements through February 1984, are being formatted into four typical weeks, one for each season, by Hawaii Natural Energy Institute under a SNLA contract. These data will be used in a Molakai system model to verify predicted parabolic dish/electric system performance of the system selected for the Molokai SCSE.

MAINTENANCE HOURS SUMMARY

	BDM		ACUREX		SKI**		CEI	
	Skid	Coll	Skid	Coll	Skid	Coll	Skid	Coll
April	0	0	0	0		0	1	0.6
May	3.0	0.7	0	0.9		0	6	0

* Average hours of maintenance normalized to one drive group. Manufacturer supplied parts unless otherwise noted.

**SKI skid is on loan.

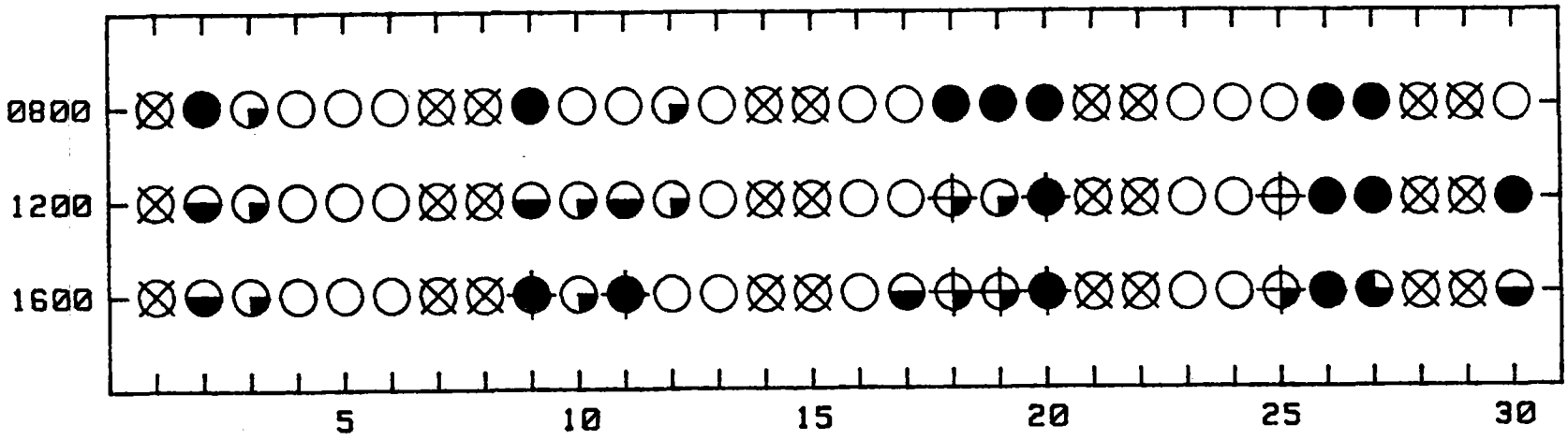
LIFE CYCLE SUMMARY

	BDM	ACUREX		SKI	CEI	FOSTER WHEELER		
		Hoses	Rot Jnts			Rot Jnts	Hoses	Coll
Prior Months	875	4431	2433	0	1687	1161**	339	1500
April	0	278	278	0	762	0	0	0
May	0	117	117	0	566	0	0	0
Total	875	4826	2828	0	3015	1161	339	1500

* Life cycling suspended due to flexible hose failures

**Life cycling suspended pending installation of new rotary joints; at that time, it will be continued with two rotary joints and two flexible hoses.

MISR SITE WEATHER DATA
APRIL, 1984

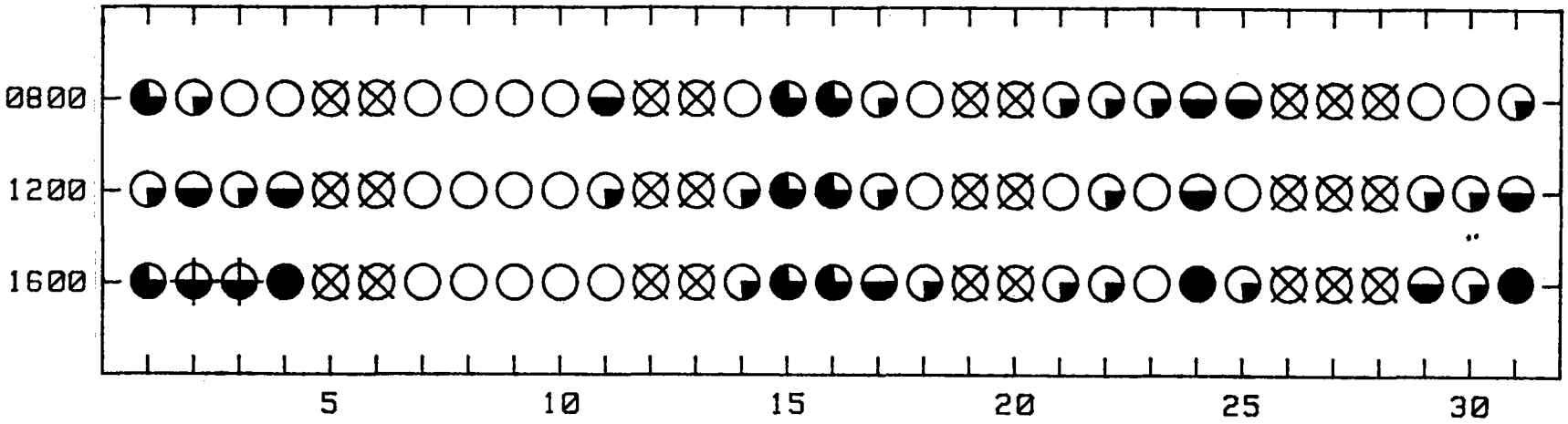


KEY

○ CLEAR	◕ MOSTLY CLOUDY
◔ MOSTLY CLEAR	● CLOUDY
◒ PARTLY CLOUDY	⊕ HIGH WINDS

⊠ TEST SITE NOT MANNED

MISR SITE WEATHER DATA
MAY, 1984



KEY

○ CLEAR	◕ MOSTLY CLOUDY
◔ MOSTLY CLEAR	● CLOUDY
◒ PARTLY CLOUDY	⊕ HIGH WINDS

⊠ TEST SITE NOT MANNED

Small Community Solar Experiments

Evaluation of the proposals received by the DOE has been completed. Replies from the proposers to questions arising during the evaluation have been received and are being evaluated for their effect on the initial scoring of the technical evaluation.

3.5 Technology Transfer

During this reporting period, seven written responses were provided to requests for information on various solar energy applications. Telephone contacts number approximately 10-20 per day.

A request has been received from a Colorado company which is planning to respond to SERI's Innovative Concepts RFP. The company asked that Sandia commit to provide sol-gel anti-reflective coatings on several borosilicate glass cylinders in the event the company is successful in winning a contract. The request is reasonable in that the SNLA capability was established at DOE expense and comparable capabilities are not available commercially or at other government-funded institutions. Because the facility has been dismantled for upgrading and relocation, it was not possible to provide a firmly scheduled commitment. However, we have expressed our support for pursuit of this concept and our intent to provide the necessary experimental coatings subject to definition of sample specifications and a schedule which we can accommodate. Note: Several firms attended a Sandia-hosted Sol-Gel Technology Transfer Workshop last fall, but none have chosen to establish a coating capability.

TECHNICAL APPROACH OR WORK PLAN CHANGES

None to report.

VARIANCES

The third test to be performed in the Shenandoah evaluation program was TOP-BF-123. This experiment calls for the fossil-only mode of operation and a constant power output, electrical-only, of 300 kWe for one hour of operation. The 300 kWe power load was attempted at 700 psig-650^{o}F steam, but the load could not be maintained. After several attempts, a constant maximum power level of 225 kWe was produced for 60 minutes. Subsequent experiments by Georgia Power personnel indicate that 300 kWe is feasible when operating in the hybrid mode. This leads us to believe that the steam generator and electrical generator are functioning normally and that degradation of the

fossil fired heater is responsible for the decreased power output. The present view of Georgia Power and Sandia is that the test should be considered complete because the time and money required to repair or replace the fossil fired heater does not justify the increased steam output necessary to generate an additional 75 kWe.

Open items

None

FORECAST FOR NEXT REPORTING PERIOD

3.1 Shenandoah Evaluation

3.2 IPH Projects

Capitol Concrete Products - The jack screw that drives the elevation control for the PKI concentrator will be replaced, a new operator will be trained, and the solar IPH system will resume operation.

Lone Star Brewery - Conversion of the IPH system from mid-temperature organic heat transfer fluid to low temperature water will be completed, the system will be checked out, and operation will be resumed. DOE/ALO will issue a change order for installing winsmith drives.

Southern Union Refining Company - The final report covering Phase III, Operation and Evaluation, will be published by Energetics.. Leaking receivers will be repaired permitting resumption of full field operation.

Retrofit of flex hoses at USS CHemicals Co. will be completed, and operation of the IPH system will be resumed. The operational period under the cooperative agreement with Columbia Gas will expire in July. The cooperative agreement has been extended to September 30 to permit preparation and publication of a final report.

The contract with Foster Wheeler for the operation of the IPH system at Dow Chemical Company will expire.

3.3 MISR

Life cycle testing of the Acurex qualification test system will continue. One drive group will be retrofitted with sagged glass mirrors and performance measurements of that group will begin.

Performance measurements at operating temperatures will continue for the FEK-244, ECP-300X, and glass reflective surfaces on the BDM MISR system.

Life cycle testing of the Custom Engineering qualification test system will continue.

Foster Wheeler will install two rotary joints in their qualification test system at SERI. Testing of these joints will begin.

3.4 Dish Electric Field Experiment Support

An inventory of meteorological instruments purchased by JPL for the SCSE projects has been requested by DOE/AL for transfer of the instruments to SNLA. When received, instruments will be installed on Molokai to measure the climatological parameters near the town of Kuanakakai. Hawaii Natural Energy Institute (HNEI) will monitor the instruments and report the data.

Four seasonal weeks of typical insolation data for Kuanakakai, Molokai will be received from HNEI for SNLA's use in a model for the Molokai SCSE.

Problem Areas

An objective of the DOE is to complete 28 of 29 priority Shenandoah tests by September 30, 1984. The 29th test has been designated for the winter solstice and is scheduled for December. Projections of this schedule indicate that testing is currently eight weeks behind schedule, assuming that one test will be performed each week. The currently projected completion date is November 30, 1984. Six of eleven fossil-only tests have been performed. The remaining tests, hybrid and solar-only, require clear sunny days. Their availability becomes more of a factor as the time left for the program decreases. Performance of the Shenandoah Solar Total Energy System is being evaluated by Sandia with support from SERI and Cal Poly. This work is scheduled for completion in February, 1985.

Number: 4
Date: June 1984
Period: 04/01/84 - 05/31/84
BR Code: EB 0201

PROJECT

Title: Solar IPH Projects (AOP Task 3.2)

CONTRACT
Number: --
Start Date: 1977
Completion Date: Continuing
Contractor: Sandia National Laboratories, Albuquerque, NM 87185

ACCOMPLISHMENTS

3.0 Solar IPH Project

Description--The solar IPH project was initiated by DOE in 1976. It consisted of 17 solar IPH experiments located at various industrial plants around the country. The experiments were conducted in 3 phases, design, construction, and operation. Upon completion of the experiments, ownership of the solar energy systems are transferred to the owners of the industrial plants. Of the 17 experiments, 14 have been completed. Of the 3 remaining experiments, 2 are in the operational phase and one, Lone Star Brewery, is being converted from a mid-temperature system using an organic heat transfer fluid to a low-temperature water system. Of the 14 experiments that have been completed, 11 IPH systems are still active. IPH systems are active at two additional locations, Capitol Concrete, Topeka, KA, and Georgia Power, Atlanta, GA, and are monitored under this project. A summary of activities for the IPH systems for April 1984 and May 1984 follows.

Objective--The objective of the solar IPH project is to evaluate the technical feasibility of solar thermal energy for industrial process heat applications. For this project, Sandia provides technical and administrative support to DOE/ALO who manages a group of experiments that are currently in the operational phase. The task provides a focal point for reporting system performance and operation and maintenance (O&M) data for the IPH experiments.

Site Activities (DOE Supported)

Caterpillar Tractor Co., San Leandro, CA (SWRI)

The solar IPH system at Caterpillar Tractor Co. continues to operate routinely. The Caterpillar plant, which was on a reduced production schedule for the past several months, has resumed full production. As a result, energy demand has increased so that the full IPH collector field is now in service. However, upon occasion output from the collector field still exceeds energy demand

from the plant causing the outlet temperature to increase beyond acceptable limits. Limit switches will then close and cause the collector array to unfocus until the fluid temperature decreases below the set point. At times, the system cycles from focus to defocus and back to focus at a frequency on the order of 10 minutes. The system is being operated in this manner to maximize energy output from the collector field over the entire day, although collector daily efficiency per unit area is reduced.

Now that more of the system is operating, some problems are occuring which require maintenance. The majority of the failures are related to the hydraulic oil system. Several seals have failed, which Caterpillar Tractor Co. personnel believe is due to the high pressures being maintained. As these seals are replaced, the pressure limit setting on the switch is being reduced to prevent seal blowouts. A site visit by SwRI personnel is planned for early June to review system status and perform DAS maintenance.

Boeing Aerospace Co. personnel visited Caterpillar Tractor Co. in the course of preparing an evaluation of the IPH system. Boeing is under contract to EPRI to prepare a set of data sheets and independent evaluations for several solar energy systems.

Lone Star Brewery, San Antonio, TX (SWRI)

Conversion of the solar IPH system at the Lone Star Brewery is nearing completion. The system is being converted from an oil heat transfer fluid to water, and from mid-temperature to low-temperature operation. Modifications to the collectors have been completed, along with modification of collector field piping and installation of the pump and heat exchanger. Start-up of the system was getting underway as this reporting period ended.

U.S.S. Chemical Co., Haverhill, OH (Columbia Gas Service)

The solar IPH system at USS Chemicals Co. is operating routinely. Steam production is running at 8,000 lb/h with good insolation. During April, five of the 60 solar collector drives were inoperable due to a lack of spare parts for the drive pylons. Hydraulic pumps for the drive pylons are on order. There was a demand for more 50-pound steam than could be delivered by the solar energy system at all times during April. The solar energy system utilization factor was 100 percent. Neither the solar energy system nor the USS Chemicals plant were down anytime during the month of April.

Site Activities (Owner Operated Systems)

Campbell Soup, Sacramento, CA (Acurex)

Installation of a voltage control unit appears to have corrected the problems previously encountered with the Autodata 10 data

acquisition system. The first 30 day printout appears reasonable. The results will be included in the next report. The system continues to operate well in supplying heat to the process.

Representatives from Sandia and ETEC visited the solar IPH system at Campbell Soup Co. on May 9. The system, a combination of flat plate collectors and parabolic troughs, heats water for washing cans and normally operates automatically whenever weather permits. The system is checked at least once a day. Maintenance personnel estimate that the system provides about $8000 worth of energy a year. The collector field appears to operate almost trouble free; however, water was leaking at two rotary joints near the junction of the flex hoses. The collectors are washed about every two weeks.

Capitol Concrete Products, Topeka, KS

The solar IPH system at Capitol Concrete Products was inoperative throughout April and May because of a worn jackscrew. A new plant superintendent has been hired and will be trained to operate the system. A small contract has been initiated by Sandia with Power Kinetics, Inc., to service the system for one year and to train a new operator. Power Kinetics has agreed to make minor repairs at no cost. The system will be operated by Capitol Concrete so long as nothing major happens to the system.

Repair of the Capitol Concrete PKI collector is scheduled to begin early in June.

Dow Chemical Co., Dalton, GA (Foster-Wheeler Development Co.)

Operation of the IPH system was transferred to Dow Chemical Company from Foster Wheeler Development Corp. at the beginning of April. Foster Wheeler will continue to report performance data on the system under a contract with Sandia. The availability of the system was 100% in April, but poor weather conditions limited operation. The system is operating with one row down pending repair of a control board. Insolation data was not available in April and May because of a faulty pyrheliometer. The pyrheliometer has been repaired and returned to the site for installation.

Georgia Power, Atlanta, GA (Herry/Jacobs Engineering)

During the months of April and May, the IPH system at Georgia Power was operated with 5/6ths of the collectors restored to full service. The remainder of the collector array was still under repair due to freeze damage and was expected to be operational by the end of May. All of the receiver tubes for the field have been repaired and pressure checked, but about 60 glass cover tubes are needed to complete the full field. The system was tested at 5/6 capacity for about 18 days in April at temperatures up to 300°F, and no leaks were observed. Starting June 1, 1400 collectors will be operating.

On March 19, 5/6ths of the array was restored to operation, but cloudy weather, the reduced collector area, and operational probems have contributed to low utilization. The thermal utilization loop operated 4 1/2 days in March and 6 days in April, supplying energy for domestic hot water, building heating, and cooling. The absorption chiller provided approximately 2,200 ton-hours of cooling in April. Performance data on the system is summarized below:

	INSOLATION IN PLANE OF COLLECTOR GJ	ENERGY DELIVERED GJ	SYSTEM THERMAL EFFICIENCY %
MONTH - MARCH	174.3	43.8	25.1
CLEAR DAY - MARCH	48.5	13.1	27.0
MONTH - APRIL	297.0	73.4	24.7
CLEAR DAY - APRIL	48.5	17.4	35.9

Home Laundry, Pasadena, CA (Jacobs Engineering)

The final report on the IPH system at Home Laundry is being reviewed. The system has been dismantled.

Johnson & Johnson, Sherman, TX

In general, the system has performed well since its startup in March. Only minor problems with tracking and steam flowmeter circuit boards have been encountered. Spare parts have been ordered along with a board for the flowmeter. Acurex will send a field technician to Johnson & Johnson in July to check out the system.

Lamanuzzi and Pantaleo, Fresno, CA (California Polytechnic State University)

Startup and checkout of the system is scheduled for mid-June. Clear day performance data will also be collected at that time. Installation of the modem linking the system to Cal-Poly for data gathering will be installed during the next report period. Operation of the system for the raisin drying process will begin in mid-August. Representatives from Sandia and ETEC visited the solar IPH project on May 8. The system, although not presently in use, appears to be in relatively good condition.

Riegel Textile Corp., La France, SC (SWRI)

Acceptance testing by ETC and correction of all deficiencies by the contractor have been completed, and the project has been turned over to Riegel for operation and maintenance. The system has performed well over the report period. Calibration of flowmeters, RTDs, and associated electronic equipment is in process.

Southern Union Oil Refining Co., Lovington, NM (Energetics)

Operation of the IPH system at Southern Union Refining Company was transferred to the refinery from Energetics at the beginning of April. On March 30, the system was damaged by high winds. As a result, one of 6 rows of collectors was shutdown and 3 collectors had to be replaced. The collectors were replaced by Solar Kinetics, Inc., under contract to Sandia. Subsequently, a second row of collectors was shutdown because of oil leaks at the receiver joints. These leaks will be repaired by Solar Kinetics under contract to Sandia. In the meantime, the system is being operated by Southern Union with five rows up. A small contract has been placed with Southern Union to provide operating information. A wind fence is planned to prevent wind damage in the future.

A draft of the final project report has been received. Final publication is awaiting approval by DOE.

OPEN ITEMS

Open IPH project activities include completing the final reports for the Home Laundry IPH experiment by Jacobs Engineering, scheduled for May 1984, Dow Chemical Co. for July 1984, and Southern Union Refining Co. for June 1984.

PROJECT DESCRIPTION AND STATUS

Table 1 provides a physical description of each project and Table 2 the current status.

PERFORMANCE

Performance of solar IPH projects is summarized in this section for those projects that are currently operating under DOE funding. For these projects, data is collected and reported monthly to DOE in accordance with contractual requirements that specify a special SERI format.* Monthly totals from the contractors reports are reported in this section so that readers may follow current energy production from the projects. Both long-term performance (Tables 3 and 4) and short-term (Clear-day, Table 5) performance are summarized. Reliability of the solar energy equipment and the operational efficiency of a particular application are determined by the portion of available solar energy that is converted to useful thermal energy over the long term. Hence, long-term, energy production is of prime interest.

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* SERI/MR-632-714, "Monthly Reporting Requirements for Solar Industrial Process Heat Field Tests", C. F. Kutscher and R. L. Davenport, September 1980.

TABLE 1

PHYSICAL CHARACTERISTICS
IPH SOLAR PROJECTS SUMMARY

PROJECT	COLLECTOR TYPE	COLLECTOR AREA m^2	HEAT TRANSFER FLUID	COLLECTOR FLUID TEMPERATURE	STEAM PRESSURE PSI	RATED CAPACITY, STEAM PRODUCTION LB/HR	PERCENT OF TOTAL PLANT LOAD	DESIGN ENERGY DELIVERY MBTU/YR
CAPITOL CONCRETE TOPEKA, KS	Power Kinetics Point focus	80.4	Water	300°F	45	174.5	3.0	100
CATERPILLAR TRACTOR SAN LEANDRO, CA	Solar Kinetics T-700 Parabolic Trough	4682.2	Water	235°F	--	--	60.0	14,000
DOW CHEMICAL CO. DALTON, GA	Suntec/Hexcel Parabolic Trough	922.5	Dowtherm LF	510°F	150	1,500	2.5	2,536
HOME LAUNDRY CO. PASADENA, CA	Jacobs/Del Parabolic Trough	603.5	Water	420°F	110	900	15.0	1,200
LONE STAR BREWERY SAN ANTONIO, TX	Solar Kinetics T-700 Parabolic Trough	877.9	Water	230°F	--	--	--	--
ORE-IDA FOODS ONTARIO, OR	Suntec-SH1655/ Hexcell Parabolic Trough	884.4	Water	486°F	300	1,930	1.9	2,700
SOUTHERN UNION REFINING CO. LOVINGTON, NM	Solar Kinetics T-700 Parabolic Trough	936.5	Texatherm	375°F	170	1,800	9.0	3,300
USS CHEMICALS CO. HAVERHILL, OH	Solar Kinetics T-700 Parabolic Trough	4682.3	Therminol 60	425°F	52	10,430	0.5	12,000
CAMPBELL SOUP CO. SACRAMENTO, CA	Western Solar Develop., Flat Plate, Acurex Parabolic Trough (Upgrade)	371.6 278.7	Water	195°F				1,800
GILROY FOODS GILROY, CA	GE TC-100 Evacuated tube (Upgrade)	552.8	Water	194°F				2,400
JOHNSON & JOHNSON SHERMAN, TX	Acurex 3001-03 (Coilsak) Parabolic Trough	1068.0	Water	375°F	160	1,200	2.0	1,500
LA COUR KILN CO. CANTON, MS	Flat plate, Chamberlain (Upgrade)	234.1	Water/Air	200°F				
RIEGEL TEXTILE CO. LA FRANCE, SC	Flat plate, Hyperion (Upgrade)	620.6	Water/glycol	100°F			2.0	
YORK BUILDING PRODUCTS CO, INC. MIDDLETOWN, PA	Linear, concentrating single-axis tracking, fixed receiver	836.0	Water	200°F			33.0	
LAMANUZZI AND PANTALEO FOODS, FRESNO, CA	Flat plate, site built	2006.7	Air	185°F			7.0	3,672
GEORGIA POWER ATLANTA, GA	Jacobs/Del parabolic trough	2203.0	Water	340°F			18.0	5,616

TABLE 2

IPH PROGRAM STATUS

PROJECT	PHASE I STARTED	PHASE I COMPLETE	PHASE II COMPLETE	UPGRADE COMPLETE	ACCEPTANCE TEST	END OF CONTRACT	ACTIONS PENDING
CAMPBELL SOUP CO. SACRAMENTO, CA				6/82	7/82	9/82	
CAPITOL CONCRETE TOPEKA, KS	1/81	9/81	5/82		8/82	12/82	
CATERPILLAR TRACTOR SAN LEANDRO, CA	9/79	7/80	11/82		2/83	9/84	
DOW CHEMICAL CO. DALTON, GA	9/78	9/79	1/82		11/81	7/84	FINAL REPORT
GEORGIA POWER ATLANTA, GA	78	1/81	10/82		10.83	10/83	
GILROY FOODS GILROY, CA				10/81		9/81	
HOME LAUNDRY CO. PASADENA, CA	9/77	1/81	4/82		4/82	5/84	FINAL REPORT
JOHNSON & JOHNSON SHERMAN, TX	7/77	12/78	12/79	---	2/80	3/81	
LA COUR KILN CO. CANTON, MS				5/82	5/82	3/82	
LAMANUZZI AND PANTALEO FOODS FRESNO, CA	5/76	4/77	5/77	6/82	4/77	6/82	
LONE STAR BREWERY SAN ANTONIO, TX	9/78	9/79	12/81		1/82	11/84	CONVERSION FROM OIL TO WATER
ORE-IDA FOODS ONTARIO, OR	9/78	7/80	8/81		6/81	3/83	
RIEGEL TEXTILE CO. LA FRANCE, SC				6/83	10/83	8/83	
SOUTHERN UNION REFINING CO. LOVINGTON, NM	9/78	9/79	1/82		1/82	6/84	FINAL REPORT
USS CHEMICALS CO. HAVERHILL, OH	9/79	11/80	3/82		5/82	9/84	FLEX HOSE REPLACEMENT, AND SPARE PARTS PROCUREMENT

TABLE 3

IPH MONTHLY PERFORMANCE STATUS
FOR MARCH 1984

PROJECT	COLLECTOR ARRAY SIZE m^2	INSOLATION IN PLANE OF COLLECTOR GJ	ENERGY DELIVERED GJ	SYSTEM THERMAL EFFICIENCY %	COMMENTS
CATERPILLAR TRACTOR SAN LEANDRO, CA	4,682.3				SYSTEM AVAILABLE FOR OPERATION THROUGHOUT MARCH; DAS PROBLEMS RESULTED IN 3 ENTIRE AND 2 PARTIAL DAYS OF LOST DATA
Current Month		852	184	21.6	
Cumulative, 17 Months		7434	2005	27.0	
DOW CHEMICAL CO. DALTON, GA	922.5				SYSTEM OPERATIONAL ALL MONTH, BUT PYRHELIOMETER FAILURE PRECLUDED INSOLATION DATA COLLECTION
Current Month		--	--	--	
Cumulative 6 Months		1633	247	15.1	
SOUTHERN UNION REFINING CO. LOVINGTON, NM	936.5				SYSTEM OPERATED 21 DAYS; DOWNTIME MAINLY DUE TO SYSTEM FINAL ADJUSTMENT AFTER UPGRADE
Current Month		241	73	30.1	
Cumulative, 24 Months		3571	741	20.8	
USS CHEMICALS CO. HAVERHILL, OH	4682.3				SYSTEM OPERATED ALL MONTH WITH 7 HOURS OF LOST COLLECTOR OPERATION TIME
Current Month		798	143	17.9	
Cumulative 14 months		17453	3905	22.4	

TABLE 4

IPH MONTHLY PERFORMANCE STATUS
FOR APRIL 1984

PROJECT	COLLECTOR ARRAY SIZE m^2	INSOLATION IN PLANE OF COLLECTOR GJ	ENERGY DELIVERED GJ	SYSTEM THERMAL EFFICIENCY %	COMMENTS
CATERPILLAR TRACTOR CO. SAN LEANDRO, CA	4,682.3				SYSTEM AVAILABLE FOR OPERATION THROUGHOUT APRIL; 5 TO 10 DRIVE ROWS WERE INOPERATIVE ON SEVERAL DAYS PRIMARILY DUE TO HYDRAULIC SEAL LEAKS; DAS DOWN 2 DAYS
Current Month		734	214	29.2	
Cumulative, 18 Months		8168	2219	27.2	
DOW CHEMICAL CO. DALTON, GA	922.5				SYSTEM OPERATIONAL ALL MONTH, BUT PYRHELIOMETER FAILURE PRECLUDED INSOLATION DATA COLLECTION
Current Month		--	--	--	
Cumulative 6 Months		1633	247	15.1	
USS CHEMICALS CO. HAVERHILL, OH	4682.3				SYSTEM OPERATED ALL MONTH WITH 5 OF THE 60 SOLAR COLLECTOR DRIVES DOWN FOR SPARE PARTS FOR THE DRIVE PYLONS
Current Month		1287	341	26.5	
Cumulative 15 months		18740	4246	22.7	

Table 5

Clear Day Performance

Project	Energy Incident in Plane of Collector (GJ)	Energy Delivered To Process (GJ)	System Thermal Efficiency (%)
	MARCH		
Caterpillar Tractor Co.	57.2	22.2	38.8
Dow Chemical Co.	--	6.2	--
Southern Union Refining Co.	22.0	6.9	31.4
USS Chemicals Co.	80.4	32.1	40.0
	APRIL		
Caterpillar Tractor Co.	52.6	21.6	41.1
Dow Chemical Co.	--	6.6	--
USS Chemicals Co.	127.2	55.8	43.9

Long-term performance is compared with theoretical performance (Tables 6 and 7) to give the reader a better understanding of what might be expected in the way of energy production at each location. Theoretical performance was calculated by SERI using their SOLIPH code and Typical Meteorological Year (TMY) weather data. Actual weather conditions might vary plus or minus 10% from the TMY data on a yearly basis. To compensate for this variation, the theoretical values used in this report for energy delivered have been adjusted by multiplying them by the ratio of the measured energy in the plane of the collector to the theoretical energy in the plane of the collector. (Efficiencies are based on energy in the plane of the collector.) Another variation between measured and theoretical insolation results from the location of the instrumentation. At some of the sites, insolation in the plane of the collector is measured by pyranometers mounted on the collectors and is measured only when the collectors are in focus. TMY data provides statistically derived insolation from sunrise to sunset. This is one reason why the theoretical values are, in general, significantly greater than the measured values. Comparison of measured energy production with theoretical energy production is not a requirement of the SERI reporting format.

TABLE 6

COMPARISON OF ENERGY PRODUCTION WITH THEORETICAL - MARCH 1984

Project	Energy in Plane of Collector (GJ)	Energy Delivered To Process (GJ)	Comments
Caterpillar Tractor Co.			
Theoretical:	1473	728	SYSTEM AVAILABLE FOR OPERATION
Adjusted Theoretical:	852	421	THROUGHOUT MARCH; DAS PROBLEMS
Actual:	852	184	RESULTED IN 3 ENTIRE AND 2 PARTIAL DAYS OF LOST DATA
Southern Union Refining Co.			
Theoretical:	526	164	SYSTEM OPERATED 21 DAYS; DOWNTIME
Adjusted Theoretical:	241	75	MAINLY DUE TO SYSTEM FINAL ADJUST-
Actual:	241	73	MENTS AFTER UPGRADE
USS Chemicals Co.			
Theoretical:	760	250	SYSTEM OPERATED ALL MONTH WITH
Adjusted Theoretical:	798	263	7 HOURS OF LOST COLLECTOR
Actual:	798	143	OPERATION TIME

NOTES: (1) Complete data not reported for Dow Chemical Co. (pyrheliometer failure)
(2) The theoretical value for energy delivered has been adjusted for the difference between TMY and measured data by multiplying by the ratio of the measured energy in the plane of the collector to the theoretical energy in the plane of the collector.

TABLE 7

COMPARISON OF ENERGY PRODUCTION WITH THEORETICAL - APRIL 1984

Project	Energy in Plane of Collector (GJ)	Energy Delivered To Process (GJ)	Comments
Caterpillar Tractor Co.			
Theoretical:	2214	1181	SYSTEM AVAILABLE FOR OPERATION
Adjusted Theoretical:	734	392	THROUGHOUT APRIL; 5 TO 10 DRIVE
Actual:	734	214	ROWS WERE INOPERATIVE ON SEVERAL DAYS PRIMARILY DUE TO HYDRAULIC LEAKS; DAS DOWN 2 DAYS
USS Chemicals Co.			
Theoretical:	1152	445	SYSTEM OPERATED ALL MONTH WITH
Adjusted Theoretical:	1287	497	4 HOURS OF LOST COLLECTOR
Actual:	1287	341	OPERATION TIME

NOTES: (1) Complete data not reported for Dow Chemical Co. (Pyrheliometer failure).
(2) The theoretical values for energy delivered has been adjusted for the difference between TMY and measured data by multiplying by the ratio of the measured energy in the plane of the collector to the theoretical energy in the plane of the collector.

In addition to the energy production summaries, "availability" and "utilization" for each of the projects is reported (Table 8). Availability is the measure of mechanical reliability of the solar energy system. Utilization is an indication of the extent to which the industrial plant makes use of the solar energy system when it is available.

OPERATION AND MAINTENANCE SUMMARY

An O&M summary (Table 9) is included with this report.

Table 8

Availability and Utilization

Project	Availability (%)	Utilization (%)
	MARCH	
Caterpillar Tractor Co.	100	87
Dow Chemical Co.	97	100
Southern Union Refining Co.	84	100
USS Chemicals Co.	90	100
	APRIL	
Caterpillar Tractor Co.	100	83
Dow Chemical Co.	100	90
USS Chemicals Co.	100	100

TABLE 9

IPH MONTHLY SUMMARY
OPERATION AND MAINTENANCE DATA
THRU APRIL 1984

PROJECT	O&M ACTIVITY ($) ROUTINE	O&M ACTIVITY ($) NON-ROUTINE	O&M TOTAL	TAXES (PROPERTY) OR INSURANCE	PARASITICS	TOTAL COSTS	FOSSIL FUEL SAVINGS
CATERPILLAR TRACTOR							
SAN LEANDRO, CA							
Current Month			329.03			329.03	
Cumulative, 15 Months			10,256.30			10,256.30	
DOW CHEMICAL							
DALTON, GA							
Current Month					14.00	21.00	228.00
Cumulative, 11 Months			7,825.00		223.00	8,013.00	2,640.00
SOUTHERN UNION							
REFINING CO.							
LOVINGTON, NM							
Current Month				154.92	61.67	216.59	396.81
Cumulative, 18 Months	1145.00	396.00	1,571.76	2,788.56	607.56	4,967.88	3,429.90
USS CHEMICALS CO.							
HAVERHILL, OH							
Current Month			2,002.00		270.00	2,272.00	1,898.00
Cumulative, 23 Months			127,066.00		4,127.00	131,193.00	24,664.00

Number:	4
Date:	June, 1984
Period:	04/1/84 - 5/31/84
B & R Code:	EB-02-01
Project:	Distributed Receiver Technology and Applications Project
Title:	Solar Concentrator Technology Development (AOP Task 4)
Contractor:	Sandia National Laboratories, Albuquerque, New Mexico 87185

ACCOMPLISHMENTS

4.0 SOLAR CONCENTRATOR TECHNOLOGY DEVELOPMENT - A major issue affecting the growth and application of central and distributed solar thermal technology is the cost of the concentrator field. A continuing emphasis on concentrator R & D is needed. The objective of this task is to conduct R & D directed toward substantial improvements in the cost-effectiveness of solar thermal concentrators. The approaches include: investigation of innovative concentrator designs, design analysis directed toward minimizing collected energy costs, identification and development of improved concentrator components, and fabrication and evaluation of improved prototype concentrators and components.

4.1 Dish Concentrators

Concentrator Development

A week was required for technical review of the proposals received in response to DOE's PON for Innovative Dish Concentrators. These proposals were evaluated, scored, and ranked; the results of the technical review panel were supplied to the DOE selection board.

An RFQ was sent to Acurex Solar Corporation for quotation on a development effort to upgrade one drive string of their installation at MISR. The improved design uses sagged glass, a simplified support structure and potential for decreased cost. Installation at MISR will allow evaluation of performance and long term environmental durability. Contract placement is expected in July.

Reflector film samples using silver metallization for higher reflectance (.95) have been subjected to accelerated thermal cycling in test chambers for three months. Reflectance measurements were completed in April. Data indicate that total reflectance is unchanged, while specular reflectance is down slightly due to increased surface roughness -- orange peel. Changes in the adhesive which holds the film to the aluminum substrate are believed responsible for the orange peel. Data are available. The units have been returned to the chamber for an additional three months of cycling.

Structural Mirror

Optical properties of a matrix of silver coated mirror polished stainless steel coupons were measured before and after coating the coupons with protective glass by the sol-gel process. Half of the coupons had received silicon monoxide sputtered on the (sputtered) silver coating before receiving the sol-gel treatment. Three different formulations of sol-gel glass material were used; silicon dioxide, titanium dioxide, and a four-component mixture. Each was applied in various thicknesses to coupons coated with bare elemental silver, as well as to coupons with silicon monoxide over the silver. Thus, a test matrix was established whose variables are glass formulation, glass thickness, and bare silver vs. SiO/Ag. The best mirrors were those with thin coats of SiO_2 or 4-comp sol-gel on SiO/Ag. Specular reflectance was 0.90 above 4 mr aperture, compared to 0.92-0.93 for bare silver. The 2-3% loss seemed to be equally divided between absorption and scattering. Thicker coats of SiO_2 or 4-comp solgel on bare silver had significant scattering. All TiO_2 coatings have reduced hemispherical reflectance due to strong absorption at about 500 nm wavelength. The coupons are being thermally cycled in an environmental chamber with high humidity to accelerate aging effects. They will be checked periodically for change in appearance and optical properties.

4.2 Central Receiver Heliostats

The Annual Solar Central Receiver Meeting was held in San Diego in late April. A presentation was made on the subject Heliostat Development Program Overview.

The proposals received in response to SNLL's RFP on a stressed membrane heliostat were reviewed and ranked so that negotiations could begin on placement of this contract.

TECHNICAL APPROACH OR WORK PLAN CHANGES

None

VARIANCES

None

Open items

None

FORECAST FOR NEXT REPORTING PERIOD

Contracts will be placed for DOE's Innovative Dish Concentrator PON, for the stressed membrane heliostat, and for the MISR trough upgrading work.

Several of the multiple planning endeavors currently in process will be completed, and the future directions for solar thermal concentrator development will be adequately defined.

The silvered sheet metal test items will be given continued exposure in the environmental chamber with a check of optical properties at four week intervals. Additional coupons will be processed with changes in some variables, specifically firing temperature at which the sol-gel coating is densified, and possibly changes in glass formulation.

Sol-gel glass will be applied to the polished surface in various thicknesses prior to deposition of silver to determine if specularity can be improved. A plan and schedule for continuation of this activity through FY 1985 and beyond will be developed.

PROBLEM AREAS

None.

SOLAR THERMAL DISTRIBUTED RECEIVER TECHNOLOGY DEVELOPMENT
AND APPLICATIONS PROJECT MONTHLY TECHNICAL STATUS REPORT

April and May, 1984

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SERI	B. L. Butler
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0400	R. P. Stromberg
1513	D. W. Larson
1810	T. G. Kepler
1820	R. E. Whan
1830	M. J. Davis
1840	R. J. Eagan
2540	K. Gillespie
3160	J. E. Mitchell
6200	V. L. Dugan
6220	D. G. Schueler
6220	J. Hanna
6221	E. L. Burgess
6222	J. V. Otts
6222	C. P. Cameron
6223	G J. Jones
6224	D. E. Arvizu
6225	R. H. Braasch
6226	E. C. Boes
6228	J. F. Banas
6246	B. Granoff
8450	J. B. Wright
8454	J. B. Woodard
6227	J. A. Leonard (3)