SERI/MR-251-1471 September

Solar Thermal Research Program

Status Report

September 1983

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SERI

Solar Energy Research Institute

A Division of Midwest Research Institute

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Golden, Colorado 80401

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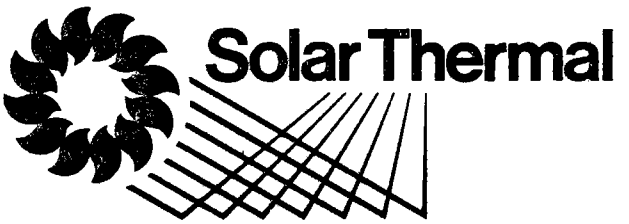
SERI/MR-251-1471 September



Solar Thermal Research Program

Status Report

September 1983

SERI

FOREWORD

SERI submits this report to provide information on technical progress in the activities under the Solar Thermal Research Program. This report summarizes the progress within each active Work Package Agreement in the Program. Included are the following: a program summary; objectives, approach and milestone chart for Work Package Agreements; Task reports; meetings and presentations; charts on resource expenditure; and a list of publications.

This report includes main elements (Work Package Agreements) for the two fiscal years:

Fiscal Year 1983	Fiscal Year 1982
o Concentrator Advanced Development	o Applied Research
o Thermal Materials Research	o Program Planning and Coordination
o Support to Systems Test and Evaluation	o Advanced Research

All Tasks in WPA 281 for fiscal year 1982 have been completed. While the effort in Solar Pond Research is no longer a direct part of the Solar Thermal Program, progress in those Tasks is included here for information.

In addition, the Solar Energy Research Institute, consistent with the contractual requirements of the Department of Energy, prepares monthly status reports on research conducted at the Institute. The executive summary of this report is included in the Institute's report. Other status reports, which include weekly reports and quarterly reviews, are sent to D.O.E. regularly. Separate technical reports provide detailed information on progress and results on specific research activities. Coordination and editorial assistance for this report were provided by W. Traugott.

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Solar Thermal Research Program
Solar Thermal and Materials Division

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MAJOR EVENT

High Temperature Receiver/Heat Transfer Research

Advanced solar thermal systems are being contemplated to meet the need of higher operating temperatures, perhaps up to 1100°C. To meet these temperature requirements, SERI is focusing on an approach different from the one presently used. Molten nitrate salts have been shown to be attractive for both receiver heat transport and thermal storage medium for temperatures up to 600°C. The Molten Salt Electric Experiment currently in design and construction at the Central Receiver Test Facility utilizes this approach.

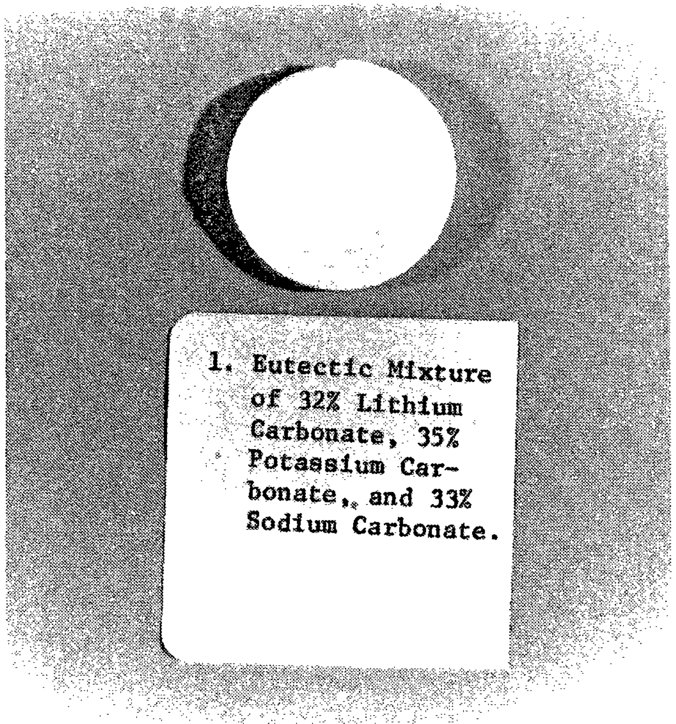
In order to achieve the higher temperatures, SERI is investigating alternative salts, e.g., carbonates, chlorides and others which are stable at the higher temperatures. Instead of heating the salt contained in a tube the concept being investigated uses a direct absorption approach to heat the salt. The molten salt flows down an insulated wall and directly absorbs the solar radiation concentrated within the cavity of a central receiver.

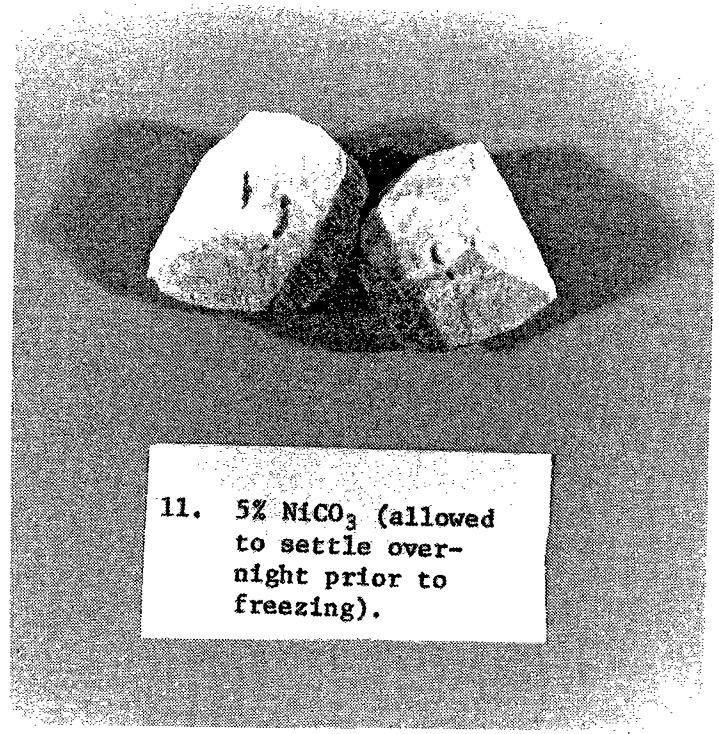
SERI's research is providing basic data which can be used with any of the candidate salts. Carbonate salts have been selected as the medium for initial experiments, since those salts have low corrosion rates on both metal alloys and ceramics. The carbonate and other salts are naturally clear in the solar spectrum; that is, they do not absorb. Sandia National Laboratory* has previously investigated means of blackening nitrate salts for a direct absorbing receiver; cobalt oxide and copper oxide were studied. SERI is also investigating the transition metal oxides (they are also identified as chromophores) as means of increasing the solar absorption of molten salts.

Figures S-1 and S-2 present photographs of the ternary eutectic of (Li, Na,K) CO_3 with and without various blackeners. In the solid state the pure salt appears white but is clear as water in the molten state. Cu_2O and CoO were added in various concentrations, and a dark liquid was obtained. However, as shown by the very dark portion of the sample, a suspension was being obtained; and, if given sufficient time, the oxides would settle to the bottom of the melt. Two of the samples were made with $CoCO_3$ and $NiCO_3$ in hopes that a solution would be formed. However, both observation and thermodynamic data show that $CoCO_3$ and $NiCO_3$ decompose to CoO and NiO at temperatures greater than 300°C; and, since the melting point of the (Li, Na, K)CO_3 is 400°C, this approach did not work.

An alternate to employing metal oxides as blackeners is to use graphite. In that case the graphite would be carried as a suspension by the salt and would be oxidized by the air inside a cavity receiver. This approach has been employed in the small particle air-cooled receiver being worked by Lawrence Berkeley National Laboratory. Although the carbon is consumed, it survives long enough to be a good solar absorber and is used in very small quantities so that its cost is small. SERI has exposed graphite rods to molten salt; the oxidation rates appear to be less than in

*Brumleve, T.D., "Status Report on Direct Absorption Receiver," SAND 78-8702, July, 1978.



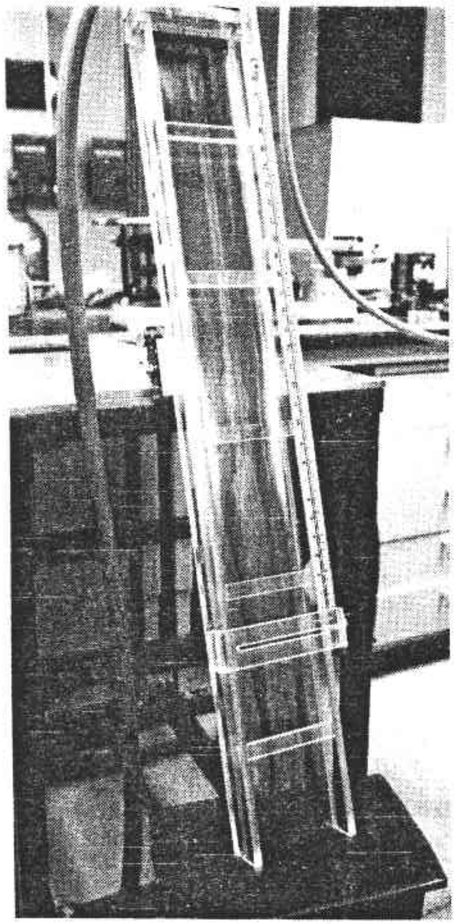


Figures S-1 and S-2. (Li, Na, K) CO_3 Eutectic With and Without Blackeners

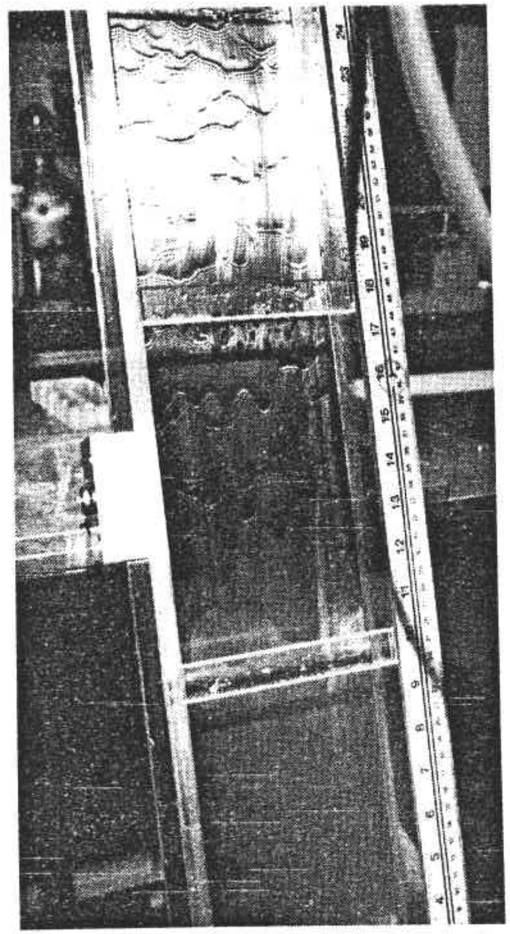
air. Either metal oxides or graphite powders will form suspensions; the mathematical modeling will be continued to analyze the heat transfer characteristics of molten salts with suspended solids.

The mathematical models have shown that the heat transfer is strongly dependent on film thickness. An apparatus was constructed by using water as the medium to measure film thickness under the same flow condition as that anticipated for a receiver. Figures S-3 and S-4 present photographs of the apparatus with flowing water which has been dyed to allow better visualization. Two greatly different flow fields are observed, even though the flow rate of water is the same. In Figure S-3 the liquid only partially covers the plate (absorber plate in a receiver)--leaving several dry spots. If such a condition occurred in the receiver, the absorber plate would be locally overheated and damage would occur. In Figure S-4 the liquid entirely covers the plate. The difference in the two flows is due to the fact that the surface was initially dry (Figure S-3 with dry spots) but in the other case, the surface was initially wetted by running a high flow rate. In Figure S-4 waves form and run down the surface; that condition causes the film thickness to vary in time at the surface. The impact on heat transfer is uncertain for the wavy flow. If the salt is blackened, the optical thickness is time-varying, and there may be areas where the surface is wetted but has minimum flow which again could lead to overheating and damage to the receiver surface. The apparatus has also been run at high flow rates. In that condition, a uniform film completely covers the plate. This flow condition is shown in Figure S-5; the flow rapidly covers the entire surface which is initially dry when the flow is turbulent (Reynolds number greater than 2000) on a smooth plate. Some limited testing has been conducted on rough surfaces which are wetted by the liquids. Better flow distribution occurs, and researchers anticipate that the heat transfer characteristics are also better. More experiments will be required to evaluate the effects of rough surfaces.

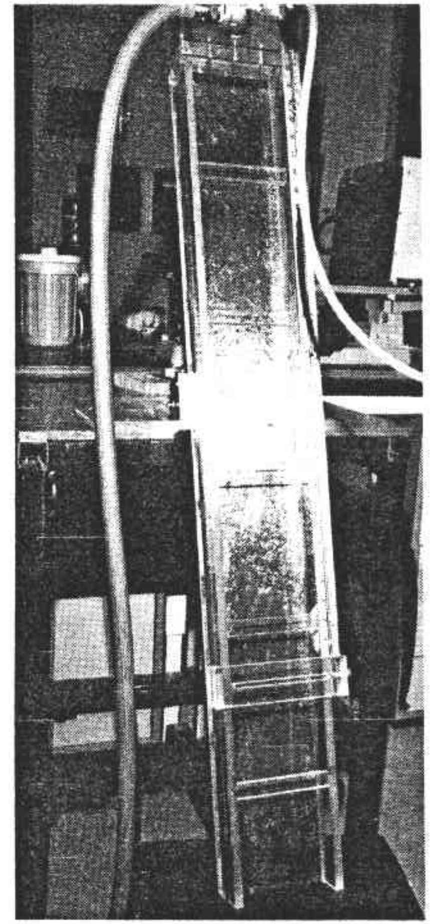
This research is providing basic data from which a direct absorption receiver can be designed. The mathematical modeling is an important tool in the design process, and the model will be expanded to provide data for suspensions and rough absorber surface (e.g., the surface on a wall of ceramic bricks). Experiments with molten salts will also be needed to verify the mathematical models.



Re = 200
S-3
Initially
Dry Surface



Re = 200
S-4
Initially
Wet Surface



Re = 2000
S-5
Wet or Dry
Initial Surface

Figure S-3, S-4 and S-5. Flow Apparatus

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- 1.2 Advanced Enclosed Thermal Dish Concentrators
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- 1.2 Laboratory Experiments On Heat and Mass Extration from Solar Ponds
- 1.3 Development of Direct Contact Heat Exchanger For Solar Pond Power
- 1.4 Solar Pond Surface Mixed Layer Studies
- 1.5 Solar Pond Instrumentation

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- 2.1 Research and Development Assessment
- 2.2 Research and Development Benefits

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- 3.1 Advanced Research Program Management Support to DOE/SAN
- 3.2 Photo-Chemical Research

*Tasks and WPA's completed have been deleted from the FY82 portion of the chart.

PROGRAM SUMMARY

WPA 416A-83 CONCENTRATOR ADVANCED DEVELOPMENT

Optical Materials Research for Polymer Mirror Development Optical characterization of 18 sets of the polymer/sputtered-silver/backing material has been completed. Weather-Ometer testing was resumed on September 16, and defective ultraviolet lamps were replaced and recalibrated. An eight-week accelerated test is planned; sample withdrawals will be made after two, four, and eight weeks. A report entitled "Parameters Influencing the Stability of Polymeric Silver Mirrors" was completed and was transmitted for delivery to D.O.E. on August 25—thus completing this Milestone. Distribution of the report was made within SERI. A drafted report describing the modification of equipment for optical characterization for evaluating metallized polymers has been prepared; the activity completes a Milestone scheduled for this month.

By using various accelerated testing, real-time exposure, and accelerated measuring techniques, researchers have identified the following parameters as adversely affecting the stability of some polymers, but not all, from FEP, PAN, Sheldahl PC, 3-M Acrylic, and PMMA: ultraviolet, 60C, 80% rh H_2O in air, chlorides as atmospheric impurities, polymeric type, polymeric purity, polymeric additives, chloride impurities at the silver/polymer interface, silver deposition method, silver corrosion, delamination, and dust. Potentially adverse parameters, which have not been studied or identified, are other atmospheric impurities, permeation of the polymer, polymer outgassing, silver purity, adhesion, catalyzed polymeric degradation at the silver/polymer interface, abrasion of the polymer, mechanical stress, and temperature cycling.

A specular reflectometer having normal incidence irradiance of the specimen and a 30 mrad acceptance aperture was assembled at SERI. Data are acquired with a multichannel analyzer and are processed by a minimcomputer. Automatic data processing enables one to make several hundred measurements and to calculate mean values and the estimated standard deviations in one day. Examples of specular reflectance measurements on specimens of polycarbonate/silver/Mylar reflector film exposed at 60°C in a Weather-Ometer for up to four weeks indicate a reproducibility of about 1 percent. The instrument can be modified easily to operate in a differential reflectance mode with

higher sensitivity to small changes in reflectance. Modifications that would allow spectral scans, mapping of the scattering in the near specular direction, and measurement of the total integrated scatter from a specimen are possible.

Several polymer-coated mirrors (FEK 244, ECP 94, PAN) are now being tested in the QUV weathering device. FEK 244 and ECP 94 are included as the benchmark examples to allow comparing this QUV device to the Atlas Weather-Ometer with regard to the rate of accelerated degradation. This calibration should allow continuation of comparative weathering tests during the time that the Weather-Ometers are inoperative because of planned laboratory moves. Eight more examples of different stabilizers added to PMMA are being prepared for optical and QUV testing. One stabilizer (National Starch) is not sufficiently soluble in toluene. Attempts to use methylene chloride result in discolored PMMA films. A second application to form a very thick film can clarify the coating. The National Starch stabilizer has probably not yet been given a fair screening.

Silver-Glass Mirror Research A memorandum summarizing the "Identified Degradation Mechanisms in Commercially Made Mirrors" was completed and was submitted for internal processing and transmission to D.O.E. The eleven-page report summarizes parts of a sixty-page appendix entitled "Physics and Chemistry of Silver-Glass Mirrors." Thus, both deliverables on this Task have been completed, and no further reports will be included.

Advanced Concentrator Research The model has been written to predict the structural deformation and the surface accuracy for the stretched membrane reflective module when the module is supported with periodic supports, and a draft report has been submitted to the Word Processing Department. The error model which uses the deformation predictions has also been coupled to the structural model, and initial runs have been started. Also, the equations for additional enhancements of the ring membrane model have been developed and will be incorporated into the numerical evaluation scheme. These enhancements include a capability to handle multiple membranes and to handle membrane attachments which do not pass through the centroid of the support ring—thus causing an initial ring frame twist prior to lateral loading of the membrane. These enhancements will allow the evaluation of two membrane-vacuum-focused modules and of the nonsymmetric tensioning of a reflector surface with a low tension wind screen on the rear surface.

The two-meter Tefzel dome at SERI has been completed and has been attached to the structural base. The structural base has been taken to the Field Site, and the dome

assembly has been inflated. The primary Milestone as originally planned has been met. The two Tefzel domes which have been ordered from Sheldahl will be retrofitted to the base as desired. Minor activities remain with the assembly. The attachment seal seems to be working well. The base will be painted and secured to the foundation piers, although some small leaks have occurred around the doors.

WPA 417A-83 THERMAL MATERIALS RESEARCH

Ceramic Materials Research An order has been placed for a diamond wire saw for preparing chevron notched bars for flexural testing. This saw together with lapping equipment that has been in storage at SERI should allow researchers to prepare flexural specimens with the required tolerance for measuring K_{IC} and K_I-V relationships. The synthesis of SiC-MgO powders at TerraTek Engineering was studied by using three carbon sources. The reacted powders were acid-leached to leave β-SiC. The largest carbon particles, graphite with a surface area of 8 m^2/g, resulted in considerable amounts of free carbon and silicon in the reacted powders. The smallest carbon particles, carbon black with a surface area of 625 m^2/g, resulted in nearly twice the volume of SiC as the graphite and very little free silicon or carbon. This powder was easily oxidized, however, when heated in air at 520°C for 16 hours. Fifteen different powders were characterized for carbon contents and were x-rayed before being sent to Dr. J. B. Holt at Lawrence Livermore Laboratories for further characterization (oxygen content, surface area and chemical analysis).

The design of the experimental apparatus at TerraTek Engineering for performing ultrasonic milling was completed in August, as well as assembling several components for fabrication of the test system.

Custom Technical Ceramics was contacted to discuss the fabrication of the specimen boat for optical measurements of molten salts at elevated temperatures. A design in which a sapphire or alumina window is clamped to the end of an alumina tube appeared to be most promising. Magnesium oxide disks could serve as a clamping ring. Tests of the concept will be conducted next month during the time that the optical system is being assembled.

High-Temperature Materials and Fluids Experiments have been started on the corrosion of 99.8 percent alumninum oxide and fused cast 94.5 percent aluminum oxide in molten

eutectic lithium-sodium-potassium carbonate (32.1 w/o, weight percent, Li_2CO_3 and 33.4 w/o Na_2CO_3) at 900°C. These materials show strong resistance to corrosion in molten eutectic sodium-potassium carbonate, and these experiments will assess the influence of lithium carbonate on corrosion rates. Lithium is needed in the carbonate system to achieve a lower melting point. Results have been obtained after three days of exposure in this experiment. It was found that the corrosion rate for the 99.5 percent alumina and the fused cast 94.5 percent alumina were 0.2μ/day and -10μ/day (a gain in mass and thickness), respectively, while in the binary eutectic $(Na,K)_2CO_3$ (51.5 percent Na_2CO_3) the corrosion rates were 0.4 and -0.9, respectively. Thus, lithium appears to have little influence on the corrosion rates for these ceramics.

Results have also been obtained after six days of exposure on 99.5 percent alumina and fused-cast 94.5 percent alumina. As is usually observed, the corrosion rates are less for the six-day results than for the three-day results. The 99.5 percent alumina showed a corrosion rate of 0.09 /day (average of three samples) while the fused cast material showed a rate of -5.3 /day (a weight gain). Both three-day and six-day corrosion rates are encouraging for long life in lithium containing salts for the 99.5 percent alumina.

For the fused cast material, a loss of weight between the three-day and six-day results indicates a corrosion rate of twoμ/day over the last three days. This result translates to about 0.030"/year, probably acceptable for use in a receiver.

Receiver/Heat Transfer Analyses were performed on a molten salt film direct absorption receiver. Additional property data on the molten carbonate were received. Viscosity data are different by more than a factor of 10 from previously received data. Some experimental data will be necessary to resolve the difference in the data.

WPA 440-83 SUPPORT TO SYSTEMS TEST AND EVALUATION

Trough/IPH Evaluations Critical review of reported data in comparison with SOLIPH predictions continued with emphasis on Home Laundry and USS Chemicals. At Home Laundry, unusually high collector and system efficiencies in the last hours of energy collection have been noted. This is probably caused by an error in radiation calculations in the site DAS software. The problem is under additional investigation by both SERI and Home Laundry. At USS Chemicals, high collector efficiencies throughout the day have been noted. However, Columbia Gas has recently made software corrections that have

not yet been reflected in a monthly report. When the next report is received, this potential problem will be analyzed.

Initial drafts of the final report have been written for three of the four major sections. These drafts are in the Word Processing Department. A complete draft should be available for internal review by the next reporting period.

An abstract was submitted for the ASME Solar Energy Division Sixth Annual Technical Conference in April, 1984, with the title "Modeling of the D.O.E. Sponsored IPH Field Test Experiment." Coauthors are A. Lewandowski, R. Gee, and K. May.

FY83 SERI SOLAR THERMAL RESEARCH PROGRAM

MILESTONE SCHEDULE

1. Concentrator Advanced Development

   a. Complete installation of the two-meter-diameter stretched membrane reflector SRE at SERI

   b. Complete detailed design of dome enclosure

   c. Release RFP for advanced enclosed dish design

   d. Install two-meter dome at SERI

2. Polymers for Enclosed Concentrators

   a. Identify ultraviolet screens and absorbers as additives

   b. Complete identification of degradation factors in polymers

   c. Modify optical characterization capabilities for metallized polymers

3. Thermal Materials Research

   a. Complete definition of requirements and recommendations for high-temperature test facility

   b. Develop requirements for high-temperature containment

   c. Complete preliminary design for high-temperature facility

   d. Complete preliminary ceramic materials testing

SERI Solar Thermal Research Program
FY 83 Milestone Schedule

Program/Task	Fiscal Year 1983											
	O	N	D	J	F	M	A	M	J	J	A	S
(1) Concentrator Research		a ▼					b ▼			c ▽		d ▼
(2) Polymers for Enclosed Concentrators						a ▼				b ▼		c ▽
(3) Thermal Materials Research						a ▼		b ▼			c ▽	d ▼

NOTE
(a) Program redirection eliminated (1)c and (3)c Milestones.
(b) Milestone (2)c was rescheduled for October, 1983.

PART I FISCAL YEAR 1983

SECTION 1

WPA 416A

CONCENTRATOR ADVANCED DEVELOPMENT

OBJECTIVE

The purpose of this research is: (a) to establish technological readiness of low-cost mirror modules and enclosures through research on polymers and other low-cost or high-performance materials and through evaluation of innovative concentrator concepts; and (b) to perform research and systems analysis and to assess the engineering and systems potential of enclosed collector concepts.

PROGRAM PROGRESS

Reports on the Tasks within this Work Package Agreement are given on the following pages.

TASK 1.1 Polymers for Enclosed Concentrators

Tasks under this activity include polymer research and polymer mirror and enclosure research for concentrators.

For work on polymers, the early years in the research will include materials testing, characterization, and evaluation. This research will be followed by: defining degradation mechanisms, interface reactions, and other phenomena; modifying existing polymers to incorporate the required characteristics; field-testing (hopefully at existing sites like CRTF and Barstow); and finally testing materials feasibility of low-cost, relatively high-performance, transmitting and reflecting polymers. Involvement of Industrial participants during all aspects in the strategy will ensure successful achievement of objectives.

For concentrator and enclosure research, the strategy is indicated in three stages. Briefly, the first stage will include systems analysis and engineering assessment to establish targets for costs on materials and components and requirements and applied research on bench-scale modules. The second and third stages will go beyond SERI's activities, will involve other laboratories, and will establish the core of a polymeric concentrator industry. This industrial base will be analogous to that already established for the steel/glass heliostat.

TASK 1.1.1 Polymer Mirror Research—A. W. Czanderna

OBJECTIVE

The objectives of this Task are: (1) to identify promising silver/polymeric materials combinations for reflector applications; (2) to perform accelerated and real-time testing of the effect of environmental conditions on the stability of the polymeric mirrors; (3) to deduce the principal mechanisms of degradation of the mirrors; and (4) to develop analytical procedures for determining a relationship for predicting real-time durability from accelerated and/or abbreviated testing.

PROGRESS

Accelerated Testing of Silvered Polymers Optical characterization of 18 sets of the polymer/sputtered-silver/backing material has been completed. Weather-Ometer testing was resumed on September 16. Defective ultraviolet lamps were replaced and recalibrated. An eight-week accelerated test is planned; sample withdrawals will be made after two, four, and eight weeks.

A report entitled "Parameters Influencing the Stability of Polymeric Silver Mirrors" was completed and was transmitted for delivery to DOE. The report was distributed with in SERI also.

Modified Optical Characterization Equipment A draft of a report describing the modification of optical characterization equipment for evaluating metallized polymers has been prepared by K. Masterson.

Ultraviolet Laser The Lambda-Physik excimer laser and dye laser were received. All components and accessories for the system, except the ultraviolet beam expander, have been received. The laser optical bench was modified to give more working room for the beam expander and power meters and to enable the use of magnetic optical mounts. The safety interlocks for the laboratory doors and the laser warning signs were completed, installed, and interfaced to the power supply for the excimer laser. Delivery of the beam expander and start-up of the system are planned for the next reporting period.

Parameters Influencing the Stability of Silvered Polymers Using various accelerated testing, real time exposure, and accelerated measuring techniques, researchers identified the following parameters as adversely affecting the stability of some polymers, but not all, from FEP, PAN, Sheldahl PC, 3-M Acrylic, and PMMA: ultraviolet, 60 C, 80% rh H_2O in air, chlorides as atmospheric impurities, polymeric type, polymeric purity, polymeric additives, chloride impurities at the silver/polymeric interface, silver deposition method, silver corrosion, delamination, and dust. Potentially adverse parameters, which have not been studied or identified, are other atmospheric impurities, permeation of the polymer, polymer outgassing, silver purity, adhesion, catalyzed polymeric degradation at the silver/polymer interface, abrasion of the polymer, mechanical stress, and temperature cycling.

Modification of Optical Measurement Capabilities—Specular Reflectometer A specular reflectometer having normal incidence irradiance of the specimen and a 30 mrad acceptance aperture was assembled at SERI. Data are acquired with a multichannel analyzer and processed by a desk top minicomputer. Automatic data processing enables one to make several hundred measurements and to calculate mean values and their estimated standard deviations in one day. Examples of specular reflectance measurements on specimens of polycarbonate/silver/Mylar reflector film exposed at 60°C in a Weather-Ometer for up to four weeks indicate a reproducibility of about 1 percent. The instrument can be modified easily to operate in a differential reflectance mode with higher sensitivity to small changes in reflectance. Modifications that would allow spectral scans, mapping of the scattering in the near specular directing, and measurement of the total integrated scatter from a specimen are possible.

TASK 1.1.2 Polymer Synthesis and Characterization—P. Schissel

OBJECTIVE

The objective of this Task is to establish an effort on polymer synthesis, modification and characterization and to initiate polymer modification to improve durability (performance over time).

PROGRESS

Several Polymer-coated mirrors (FEK 244, ECP 94, PAN) are now being tested in the QUV weathering device. FEK 244 and ECP 94 are included as the benchmark examples to allow researchers to compare this QUV device to the Atlas Weather-Ometer with regard to the rate of accelerated degradation. This calibration should allow researchers to continue comparative weathering tests during the time the Weather-Ometers are inoperative because of the planned laboratory moves.

Eight more examples of different stabilizers added to PMMA are being prepared for optical and QUV testing. One stabilizer (National Starch) is not sufficiently soluble in toluene. Attempts to use methylene chloride result in discolored PMMA films. A second application to form a very thick film can clarify the coating. The National Starch stabilizer has probably not yet been given sufficient screening.

TASK 1.2 Advanced Enclosed Thermal Dish Concentrators

This activity is investigating the feasibility of enclosures and enclosed dish concentrators for thermal and other applications. Tasks include analysis of enclosure and dish systems and an RFP to industry for design and development. It is anticipated that the innovative low-cost concentrators and enclosures will establish through industry the feasibility of meeting cost and performance targets for solar thermal energy systems. Technical issues include unidentified failure modes, cost effectiveness, beam walk-off, long-term durability, and the presence of a mid-to-high temperature heat source within the enclosure.

TASK 1.2.1 Enclosure and Dish Concept Study and Development—R. Gee/L. Murphy

OBJECTIVE

This Task performs research and systems analysis on the engineering and systems potential of polymer-based enclosures and enclosed thermal dishes, builds and tests scale-model enclosures, and extends the investigation of other innovative concentrators concepts such as the stretched membrane.

Also with this Task, research on polymer enclosure fabrication and assembly technology will be conducted, and materials performance and testing requirements, as well as research needs for polymer enclosures and materials, will be established. Specific issues to be investigated include plastic dome fabrication techniques, attachment design, seam design, engineering advantages of laminates, and increasing the tear strength of thin polymer sheets. Results of this Task will be used in the Industrial Designs Development Task to support design recommendations. Findings will be disseminated to industrial developers and other laboratories working on domed concentrators.

Through systems analysis, the dish optical thermal performances and economic potential of the concept are to be assessed (while realizing that other current research is addressing additional crucial issues in systems such as high piping and transport costs). Close coordination with the Materials Branch and the work on applicable materials will be maintained to arrive at recommendations on materials requirements and research. Coordination with related work at the Jet Propulsion Laboratory will be maintained.

A full-scale or two-meter scale dome SRE is to be configured and is to be built to test domes of various approaches to materials attachment and seaming. The SRE is to be flexible to allow relevant testing for either enclosed thermal dishes or heliostats. Research and systems analysis on innovative concentrators will continue to offer additional collector options to meet the D.O.E. value-based goals of $\$50/m^2$ and \$5/GJ delivered energy.

PROGRESS

The two-meter Tefzel dome at SERI has been completed and has been attached to the structural base. The structural base has been taken to the Field Site, and the dome assembly has been inflated. The primary Milestone as originally planned has been met. The two Tefzel domes which have been ordered from Sheldahl will be retrofitted onto the base. Minor activities remain with the assembly. The attachment seal seems to be working well. The base will be painted and secured to the foundation piers, although some small leaks have occurred around the doors.

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TASK 1.2.2 Industrial Design Development

OBJECTIVE

The objective of this Task was to develop and to release an RFP for conceptual design of enclosed thermal dishes. The resulting contracts will be managed by SERI. Due to the results of Task 1.2.1 the objectives have been redefined, and the redirected work will include research on advanced collector concepts and wind avoidance techniques for collector fields.

PROGRESS

Statements of work to initiate this effort are being prepared.

SECTION 2

WPA 417A

THERMAL MATERIALS RESEARCH

OBJECTIVE

The objective of this activity is: (a) to perform research on thermal materials and thermal fundamentals including ceramics, high-temperature receivers, storage concepts transport of heat, and heat transfer research; and (b) to develop innovative concepts for conversion of thermal energy to fuels and chemicals.

PROGRAM PROGRESS

The progress on individual Tasks is outlined on the following pages.

TASK 2.1 Receiver and Materials Research

This activity encompasses Tasks in high-temperature receiver research, high-temperature heat transfer research, ceramic materials research, facility design, and materials and fluids research.

Information from universities, from the Fuels and Chemical Subprogram, and from current large-scale experiments at CRTF, PDTS and other places is to provide response to resolve technical issues and to set initial requirements. It is anticipated that, once materials and concepts have been proven technically feasible at SERI, large-scale experiments at CRTF, GIT, and at a high-temperature dish facility will be required on some concepts to verify technical readiness. Industry will be involved in the resolution of some issues and even more heavily in the design, fabrication, and testing. Again, help of advisory panels will be sought to critique research and to recommend future directions in research.

TASK 2.1.1 Ceramic Materials Research—T. Coyle

OBJECTIVE

Receivers for solar thermal applications greater than 870° C require ceramic materials to function as absorbers, heat exchangers, and windows transparent to solar radiation. The objective of this Task is to identify suitable ceramics for these applications by characterizing the mechanical, optical, and thermal properties of candidate materials. Candidate materials initially are commercially available materials with the probable requirement that, after the first year, materials more closely tailored to suit the requirements of these applications will have to be fabricated by using laboratory or small-scale procedures in development.

PROGRESS

An order has been placed for a diamond wire saw for preparing chevron notched bars for flexural testing. This saw together with lapping equipment that has been in storage at SERI will allow researchers to prepare flexural specimens with the required tolerance for measuring K_{IC} and K_I-V relationships.

The synthesis of SiC-MgO powders at TerraTek Engineering was studied by using three carbon sources. The reacted powders were acid leached to leave β-SiC. The largest carbon particles, graphite with a surface area of 8 m^2/g, resulted in free carbon and silicon in the reacted powders. The smallest carbon particles, carbon black with a surface area of 625 m^2/g, resulted in nearly twice the volume of SiC as the graphite and very little free silicon or carbon. This powder was easily oxidized, however, when heated in air at 520° C for 16 hours. Fifteen different powders were characterized for carbon content and x-rayed before being sent to J. B. Holt at Lawrence Livermore Laboratories for further characterization (oxygen content, surface area and chemical analysis).

The design of the experimental apparatus at TerraTek Engineering for performing ultrasonic milling was completed, and several components for fabrication of the test system were assembled.

D. Mustoe of Custom Technical Ceramics was contacted to discuss the fabrication of the specimen boat for optical measurements of molten salts at elevated temperatures. A design in which a sapphire or alumina window is clamped to the end of an alumina tube appeared to be most promising. Magnesium oxide disks could serve as a clamping ring. Tests of the concept will be conducted during the time that the optical system is being assembled.

The ultrasonic generator is to have been delivered at TerraTek Engineering, and the fabrication of the test apparatus is being completed. Completion will allow ultrasonic milling studies to commence in October. The main area of emphasis will be the synthesis of SiC-Al_2O_3 powders and the densification of such powders, in addition to SiC, by hot pressing at the University of Utah. Hot-pressed discs of SiC and SiC-Al_2O_3 are to be delivered to SERI.

TASK 2.1.2 High-Temperature Facility Design and Specification—L. Murphy

OBJECTIVE

This Task is to determine the high-temperature facility requirements needed to support solar thermal and materials research at SERI. A recommended plan for the fabrication, installation, and funding levels for the test facility will be developed.

PROGRESS

The revised report entitled "Solar Thermal Research Test Facility Requirements" was approved by SERI's management and was transmitted to the D.O.E in May. Further effort to reach a design of the facility was dropped. Work was redirected to look for options rather than an outdoor facility at SERI.

TASK 2.1.3 High-Temperature Material/Fluids Research—T. Coyle

OBJECTIVE

The overall objective is to select and to qualify high-temperature structural materials and heat transfer fluids for use in solar thermal systems. One long-range objective is to qualify refractory materials for containment of working fluids at temperatures up to 1370°C by 1987. The objective is to identify containment material/heat transfer fluid pairs which are compatible at temperatures up to 1370°C and to develop some understanding of how interactions affect the mechancial properties of these containment materials.

PROGRESS

Experiments have been started on the corrosion of 99.8 percent aluminum oxide and fused cast 94.5 percent aluminum oxide in molten eutectic lithium-sodium-potassium carbonate (32.1 w/o, weight percent, Li_2CO_3, 33.4 w/o Na_2CO_3 and the balance potassium carbonate) at 900°C. These materials showed good resistance to corrosion in molten eutectic sodium-potassium carbonate, and these experiments will assess the influence of lithium carbonate on corrosion rates. Lithium is needed in the carbonate system to achieve a lower melting point.

Results have been obtained after three days of exposure in this experiment. It was found that the corrosion rate for the 99.5 percent alumina and the fused cast 94.5 percent alumina were 0.2 μ/day and -10 μ/day (a gain in mass and thickness), respectively, while in the binary eutectic (Na, K)$_2CO_3$ (51.5 percent Na_2CO_3) the corrosion rates were 0.4 and -0.9, respectively. Thus, lithium appears to have little influence on the corrosion rates for these ceramics.

Results have also been obtained after six days of exposure on 99.5 percent alumina and fused-cast 94.5 percent alumina. As is usually observed, the corrosion rates are less for the six-day results than for the three-day results. The 99.5 percent alumina showed a corrosion rate of 0.09μ/day (average of three samples) while the fused cast material

showed a rate of -5.3μ/day (a weight gain). Both three-day and six-day corrosion rates are encouraging for long life in lithium containing salts for the 99.5 percent alumina.

For the fused-cast material, loss of weight was between the three-day and six-day results and indicates a corrosion rate of 2 μ/day over the last three days. This translates to about 0.030"/year—probably acceptable for use in a receiver.

Efforts to calibrate the quadrupole mass spectrometer system for CO_2 in N_2 were hampered by contaminants in the quadrupole which had been stored in air for an extended period. The quadrupole has been cleaned; in addition, a leak seems to have occurred in the system and must be corrected before calibration can be done.

TASK 2.1.4 Receiver/Heat Transfer Research—R. Copeland

OBJECTIVE

The objective of this Task is to determine the technical feasibility of a promising concept for solar central receivers to supply high-temperature (800°C) heat for electric power production, industrial process heat, and production of fuels and chemicals. The SERI concept makes use of a molten salt which can withstand high temperatures as the working fluid in the receiver. The molten salt is directly exposed to concentrated solar radiation as a film flowing down the inner walls of a cavity receiver at atmospheric pressure. The molten salt has much better heat transfer characteristics than air. The flowing film eliminates the problem of joining tubes at high temperature. Since the receiver operates at atmospheric pressure, it may be possible to eliminate window materials.

PROGRESS

Analyses were performed on a molten salt film direct absorption receiver. Additional property data on the molten carbonate were received. Viscosity data are different by more than a factor of 10 from previously received data. Some experimental data will be necessary to resolve the differences in the data.

TASK 2.2 Advanced Research Program Management Support to DOE/SAN—B. Gupta/ G. Nix

OBJECTIVE

The objective of this Task is to provide technical support to the DOE/SAN office for the Solar Thermal Advanced Research Program (STARP)—providing technical data, specific areas of future research, and the priorities in those areas of research. Specific functions include:

- o Technical support in preparation of solicitation, as required, and in evaluation of the proposals expected;
- o Review of technical results in relation to solar thermal cost and performance goals;
- o Recommendations for research to be included in subsequent solicitations and for more detailed investigation.

PROGRESS

Status on this Task is being reported under WPA 401-82, Advanced Research, until the depletion of funds for fiscal year 1982.

TASK 2.3 Silver-Glass Mirror Research—A. W. Czanderna

OBJECTIVE

The objectives of this research include: (1) assessing the current problems and opportunities of commercially available mirrors; (2) deducing the principal mechanisms of degradation of mirrors of the type currently deployed in central receiver systems.

PROGRESS

A memorandum summarizing the "Identified Degradation Mechanisms in Commercially Made Mirrors" was completed and was submitted for internal management-processing and transmission to D.O.E. The eleven-page report summarizes parts of a sixty-page appendix entitled "Physics and Chemistry of Silver-Glass Mirrors." Thus, Deliverables for fiscal year 1983 on this Task have been completed.

2.4 Program Management—B. Gupta

OBJECTIVE

The objective of the Program Management Task is to plan, to coordinate, to evaluate, and to report on the activities of the Solar Thermal Program assigned to SERI. This activity includes the in-house SERI solar thermal effort, selected Tasks at other national laboratories, and subcontracts to industry and universities.

The Task will deliver written monthly reports of activities under its direction; quarterly review presentations; and program strategy, planning and evaluation support to D.O.E., Washington. The Task also will conduct technology-transfer activities which focus on the development, dissemination, and communication of technical information through appropriate channels to audiences involved in the Solar Thermal Program.

PROGRESS

The revised draft of the SERI Solar Thermal Research Annual Operating Plan (AOP) for Fiscal Year 1984 was completed and was submitted to D.O.E., Washington, and to TPI for review on September 9. The revised AOP was prepared in accordance with the technical budgetary and format guidelines stated in F. Morse's letter to SERI from August, 1983.

In addition, the WPP for fiscal year 1984 and the associated FTP's for the STT Research Program were revised to conform to the guidance in the aforementioned letter from Dr. Morse.

SERI staff attended and participated in the Solar Thermal Research Workshop sponsored by D.O.E. and held at the Georgia Institute of Technology on September 7 and 8. The objectives of the workshop were to:

- Report on recent technical findings;
- Identify approaches to the goal of demonstrating solar thermal feasibility.

At the workshop, the following papers were presented by SERI staff: "High Flux Photoconversion Research" by D. Johnson: "Polymer Research" by P. Schissel; "Advanced Concentrator Research" by M. Murphy, and "Direct Absorption High Temperature Receiver" by R. Copeland. In addition, G. Gross chaired the Materials Session, and B. Gupta was one of the discussion panel members.

On September 15, SERI submitted to the TPI the outline for the portions of the STT Program Annual Evaluation Report for Fiscal Year 1983 to be prepared by SERI. Coordination for preparation of the report for Fiscal Year 1983 is being handled by the TPI.

SERI staff attended and participated in the STT Program Fourth Quarter Review for Fiscal Year 1983 held at D.O.E., Washington, on September 20 to 22. As requested by D.O.E., advance copies of the SERI matrials were delivered to D.O.E., Washington, on September 16. Twenty-five copies were delivered at the beginning of the review.

As requested by Dr. Morse at the Quarterly review, SERI sent to TPI a list of research subcontracts that SERI has awarded to universities. Also, as requested by D.O.E., Washington, SERI generated a summary report—to be used in the Annual Report of the Energy Materials Advisory Committee—that describes the materials research Tasks for Fiscal Year 1983 in the SERI in-house Program and the University Research Program. It was submitted to D.O.E., Washington, on September 29 in accordance with the D.O.E. schedule.

Plans for next month include:

- Completing the final draft of the FY84 STT Research Program Annual Operating Plan and submitting it to D.O.E., Washington, and to TPI on October 7;
- Submission of the FY84 WPP and associated FTP's for the STT Research Program to D.O.E., Washington;
- Completing the SERI portions of the STT Program FY83 Annual Evaluation Report and submitting them to the TPI no later than October 14;
- Initiating the procurement process to fund research at the Georgia Institute of Technology and the University of Houston as part of the University Research activity.

SECTION 3

WPA 440

SUPPORT TO SYSTEMS TEST AND EVALUATION

OBJECTIVE

This research is intended to provide technical support to solar thermal field experiments: (1) to enhance the probability of successful operation; (2) to provide a link between research and the application of solar thermal technology; and (3) to provide a return of information to ensure that research is targeted on technological barriers and issues.

PROGRAM PROGRESS

Progress on activities is reported on the following pages.

TASK 3.1 Trough/IPH Evaluations

OBJECTIVE

The purposes of this Task are to determine the extent to which the selected IPH field experiments are delivering energy, to determine the cause of any reduced performance, and to make appropriate recommendations for current system improvements and future designs. To accomplish these goals, SERI, in conjunction with and in support of the IPH project managed by Sandia, Albuquerque, will collect performance data from the field experiments and will examine on-site problems. The field experiments will be modelled on SERI's hour-by-hour solar IPH simulation program (SOLIPH) to predict how the systems should be performing. Careful study will be made to determine the nature of any discrepancies to identify measures which must be taken to correct them. SERI analysts will be particularly alert for opportunities to validate and to improve the predictive capability of SOLIPH. Additionally, SERI will review the instrumentation and data acquisition at the selected sites to determine the adequacy of contractor-reported information.

PROGRESS

Critical review of reported data in comparison with SOLIPH predictions continued with emphasis on Home Laundry and USS Chemicals. At Home Laundry, unusually high collector and system efficiencies in the late hours of energy collection have been noted. This condition is probably caused by an error in radiation calculations in the site DAS software. The problem is under additional investigation by both SERI and Home Laundry. At USS Chemicals, high collector efficiencies throughout the day have been noted. However, Columbus Gas has recently made software corrections that have not yet been reflected in a monthly report. When the next report is received, more analysis of this potential problem will be done.

Initial drafts of the final report have been written for three of the four major sections which are in the Word Processing Department. A complete draft should be available for internal SERI review by the next reporting period.

An abstract was submitted for the ASME Solar Energy Division Sixth Annual Technical Conference in April, 1984, and was entitled "Modeling of the D.O.E. Sponsored IPH Field Test Experiment." Coauthors are A. Lewandowski, R. Gee, and K. May.

PART II FISCAL YEAR 1982

SECTION 1

WPA 279B, WPA 803

APPLIED RESEARCH

OBJECTIVE

The objective of the SERI Applied Research Subprogram is to advance the technology base through feasibility experiments and systems analysis of advanced solar thermal systems and components.

This Work Package Agreement consists of two basic activities: (1) MISR System Evaluation, and (2) Heat and Mass Extraction for Solar Ponds.

The objectives of these activities are:

- To evaluate state-of-the-art line focus solar thermal systems fabricated by industry by conducting performance testing on a prototype MISR system at a SERI field test loop. A test loop has been designed and constructed. A MISR prototype system was installed, and testing of the system was conducted by SERI at the SERI Permanent Test Site. The test data is being provided to Sandia National Laboratories, Albuquerque.
- To design and to carry out experiments in order to determine the physical factors which limit the rate at which heat and mass may be extracted from the storage layer of a salt gradient solar pond by yet untried extraction methods, and to develop concepts for new extraction methods which are more efficient and cost-effective than existing methods.

PROGRAM PROGRESS

Progress on the Tasks is reported on the following pages.

TASK 1.1 MISR Testing—J. Thornton

OBJECTIVE

The objective of the MISR (Modular Industrial Solar Retrofit) Task is to encourage the use of line-focus based solar thermal systems within industry by conducting performance testing on a prototype MISR system at a SERI field test loop. A detailed test loop was designed and constructed. Installation of the MISR prototype system followed, and qualification testing of the system is taking place.

PROGRESS

Previous testing of equipment has been reported as completed, and no further testing has occurred. A response to Sandia, Albuquerque, proposing additional MISR work on the Foster Wheeler QTS was prepared by the Program Office. That response proposes work to evaluate the new rotary joints being developed by Foster Wheeler by system operation and life cycling to be reprogrammed from existing in-house solar thermal Task 3.2 in WPA 440-83.

TASK 1.2 Laboratory Experiments on Heat and Mass Extraction from Solar Ponds—D. H. Johnson

OBJECTIVE

The objectives of this Task are: (1) to design and to carry out experiments to determine the physical factors which limit the rate at which heat and mass may be extracted from the storage layer of a salt gradient solar pond by a given extraction method; (2) to develop concepts for new extraction methods which are more efficient and more cost-effective than the existing methods.

PROGRESS

Reports on subcontracted work are the following:

Colorado State University: Experiments on bulk instabilities in a stratified fluid with nonlinear distribution of salt and heat were completed by C.S.U. personnel working with the SERI stratified fluid test tank.

Purdue University: Results of analysis of data from tests conducted last month with the small tank are available. The rate of mixed layer growth was determined from vertical temperature profiles, and patterns of fluid motion in the mixed layer were studied by using particle tracking. No conclusions have yet been drawn. Experiments on the large test cell were postponed due to leaks which were repaired. Instrumentation and data acquisition equipment and software are ready for use when experiments commence with the large tank.

University of Utah: Assembly of the experiment at the site for Utah Power and Light is approximately 90 percent completed. All major components and plumbing have been installed, and 90 percent of the wiring has been completed. Pentane for the first tests has been ordered.

TASK 1.3 Development of a Direct Contact Heat Exchanger for Solar Pond Power Production—D. H. Johnson

OBJECTIVE

The objectives of this Task are: (1) the analysis of a direct contact condenser for solar pond electric power production and; (2) a re-evaluation of a direct contact preheater/boiler for solar pond power production using data from experiments being conducted at the University of Utah.

TECHNICAL APPROACH

The approach to Objective 1 will be to develop an analytical model of a Direct Contact Condenser and to use it to evaluate the performance of a solar pond power production system by using it in comparison to one using a conventional shell and tube condenser. The approach to Objective 2 will be to use data supplied by the University of Utah to redo the analysis of a direct contact preheater/boiler that was done previously in using data from the literature.

PROGRESS

The analysis of direct-contact condensers for use with a solar-pond-driven, organic-working-fluid Rankine power cycle was completed. Three types of direct contact condensers and a conventional shell for the tube condenser were sized and costed for a 5 MW_e net power plant. The direct contact condensers were only marginally less expensive than the shell and tube condenser.

TASK 1.4 Solar Pond Surface Mixed Layer Studies—D. Johnson

OBJECTIVE

The ultimate objective of this work is to develop an inexpensive, but effective method of limiting the depth of the surface mixed layer which develops in a solar pond.

PROGRESS

Software for the computer data acquisition system was debugged. Preliminary wind-mixing tests were run. Work began on developing a theoretical entrainment model which includes double-diffusive effects. Results from M.I.T.'s grid-mixing experiments and SERI's storage layer heat and mass extraction experiments indicate that these effects are important in the solar pond.

SECTION 2

WPA 280

PROGRAM PLANNING AND COORDINATION

OBJECTIVE

The mission of the SERI Solar Thermal Program Planning and Coordination Subprogram is to identify long-term, high-payoff R.&D. options for the Solar Thermal Program, to recommend goals and objectives, and to assess potential benefits of long-term R.&D. options.

This Work Package Agreement has included the following: (1) R.&D. Assessment; (2) Systems Analysis; and (3) R.&D. Benefits. The objectives of R.&D. Assessment are: to determine energy and systems-level performance and cost goals for solar thermal technology, to identify options and to recommend priorities for long-term R.&D., and to develop a multiyear plan for solar thermal research. The objectives of Systems Analysis are: to identify and to analyze crucial performance and cost allocation targets for materials and components, and to evaluate innovative concentrator concepts using systems sensitivity analysis. The objective of R.&D. Benefits is to assess the relative benefits of various advanced R.&D. options for solar thermal systems in industrial applications.

PROGRAM PROGRESS

The Program report on each Task now in progress within this Work Package Agreement is given on the following pages.

TASK 2.1 Research and Development Assessment--R. Hewett

OBJECTIVE

The objectives of this Task are to determine and to recommend targets for energy and systems-level cost and performance for solar thermal technology based on market value; to identify options and to recommend priorities for the Solar Thermal Advanced R.&D. Program; to develop an advanced R.&D. MYPP; and to support D.O.E. Solar Thermal Technology Program in the MYPP and other planning and assessment activities.

PROGRESS

The revised draft of the report Solar Thermal Cost Goals Committee: Activities and Recommendations is scheduled for distribution to members of the Committee, now that updated addresses have been secured. Staff efforts were particularly devoted to preparation of the FY84 Annual Operating Plan and preparation of materials for the FY83 Fourth Quarter Quarterly Review. As a result, plans for next month include sending the revised draft of the report to as many members of the Committee as possible for review. After that review, SERI will prepare a final draft of the report.

TASK 2.2 Research and Development Benefits—L. Flowers

OBJECTIVE

The intent of this Task is to assess benefits of Advanced R.&D. for the industrial sector in support of the Multiyear Program Plan, Cost Goals Committee, and Sunset Review Documentation.

PROGRESS

No progress has been reported this month.

SECTION 3

WPA 401

ADVANCED RESEARCH

OBJECTIVE

The Work Package Agreement has the following as its objectives:

1. To provide technical support to the DOE/SAN office for the Solar Thermal Advanced Research Program (STARP), providing technical data, specific areas of future research and the priorities in those areas of research. Specific functions include:

   - o Technical support in preparation of solicitation, as required, and in evaluation of the proposals expected;
   - o Review of technical results in relation to solar thermal cost and performance goals;
   - o Recommendations for research areas to be included in subsequent solicitations and for more detailed investigation during Phase II of the first solicitation.

2. To conduct an effort to identify the most promising solar fuels and chemicals production based on photochemical (i.e., quantum) and thermal principles when used in a hybrid manner to enhance the overall solar conversion efficiency. Technical and economic potential and risks will be assessed.

PROGRAM PROGRESS

The Program report on each Task is given on the following pages.

TASK 3.1 Advanced Research Program Management Support to DOE/SAN—B. Gupta/ G. Nix

OBJECTIVE

The objective of this Task is to assist DOE/SAN in coordinating the effort at the two universities—the University of Houston and Georgia Institute of Technology—and to assist in the development and initiation of an advanced research program.

PROGRESS

This Task is completed. Further coordination of this effort will be reported under WPA 417-83.

TASK 3.2 Photo-Chemical Research—F. Kreith/D. Johnson

OBJECTIVE

The objective of this Task is to explore the potential of photon-enhanced processes and their applicability to solar thermal technologies. Based on the evaluation, a future effort in this long-term research will be recommended.

PROGRESS

A paper on the analysis of combined quantum/thermal conversion processes was presented to the Solar Thermal Research Workshop held in Atlanta, Georgia, on September 7 to 8, 1983.

Draft proceedings of the workshop in January, 1983, are in final stages of editing, and during this period comments from the workshop participants have been incorporated.

MEETINGS AND PRESENTATIONS

At the Solar Thermal Research Workshop in September at G.I.T., Atlanta, Georgia, the following papers were presented: "High Flux Photoconversion Research" by D. Johnson; "Polymer Research" by P. Shissel; "Advanced Concentrator Research" by M. Murphy; and "Direct Absorption High Temperature Receiver" by R. Copeland. In addition, G. Gross chaired the Materials Session, and B. Gupta was one of the discussion panel members.

T. M. Thomas attended the Conference on Surface Analysis, organized by Kratos and held in Pocono, Pennsylvania, on September 12 to 14, and he presented a paper titled "Chloride-Silver Surface Diffusion."

T. Coyle attended the presentation on August 19 at D.O.E., Washington, on a study entitled "Overview of High Temperature Structural Ceramics" prepared by Engineering and Economic Research, Inc.

Two papers were presented at the Rocky Mountain Spectroscopy Conference by J. Webb and D. Smith.

A paper was presented at the SPIE Conference in San Diego, California, by J. Webb.

External reviewers' comments have been received and have been incorporated into a paper entitled "High Temperature Molten Salts for Use in Solar Thermal Systems" to be published in the Proceedings of the Sixth International Symposium on Salt. The SERI report number is TP/3255-2001.

APPENDIX A

SUBCONTRACTS

SERI
SOLAR THERMAL ENERGY PROGRAM
SUBCONTRACT LIST

Research Area	Subject	Subcontractor	FY82 ($K)	Award Date
A Solar Pond/ORC DCHX	Laboratory Tests of a	University of Utah Brine/Pentane DCHX	100	1/83
Solar Pond Heat and Mass Exchange Research	Solar Pond Mixed Layer-Gradient Layer Interface Studies	Purdue University	70	4/83
Solar Pond Surface Mixed Layer Studies	Wind Mixing in Salt Gradient Solar Pond	Massachusetts Institute	62	6/83

TABLE
Planned Major Procurement Funded from FY 1983

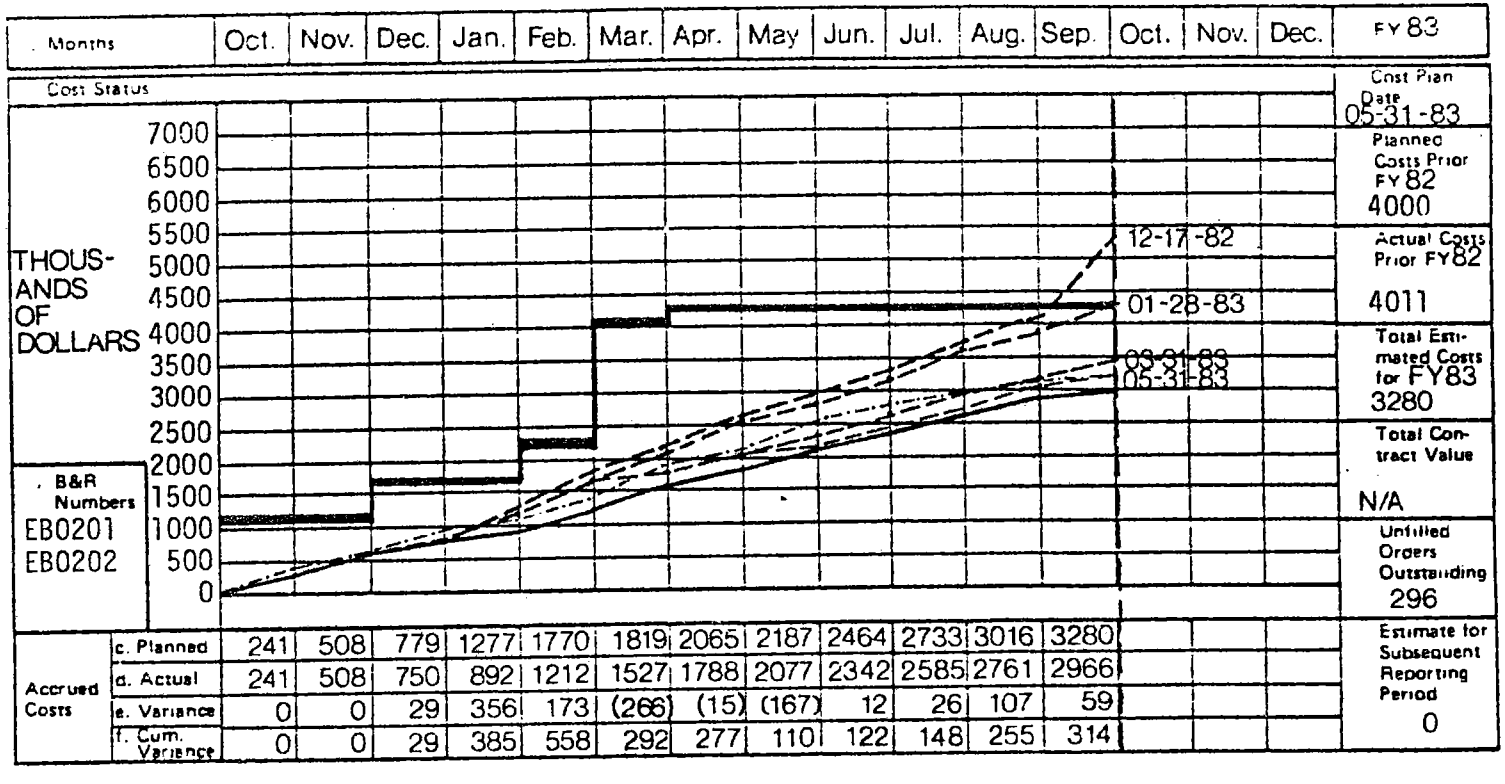
Research Area	Subject	Subcontractor	FY83 (K$)	Award Date
Optical Materials Research	Materials Outdoor Exposure	DSET, Inc.	50	12/83
	Polymers Synthesis and Modification	JPL	150	2/83
Thermal Materials Research	Investigation of Improved Properties in Densified Ceramics	Terra Tek	65	2/83
	Structural Integrity of High Temperature Ceramic Components	To be determined	85	1/83
	High Temperature Heat Transfer Fluid Thermal Diffusivity Techniques	To be determined	100	
	Thermal Science Research	To be determined	100	10/83
	Leakage through Seal Material	Barber-Nichols	15	2/83
Innovative Concepts	Multiple Subjects	To be determined	300	9/83

APPENDIX B

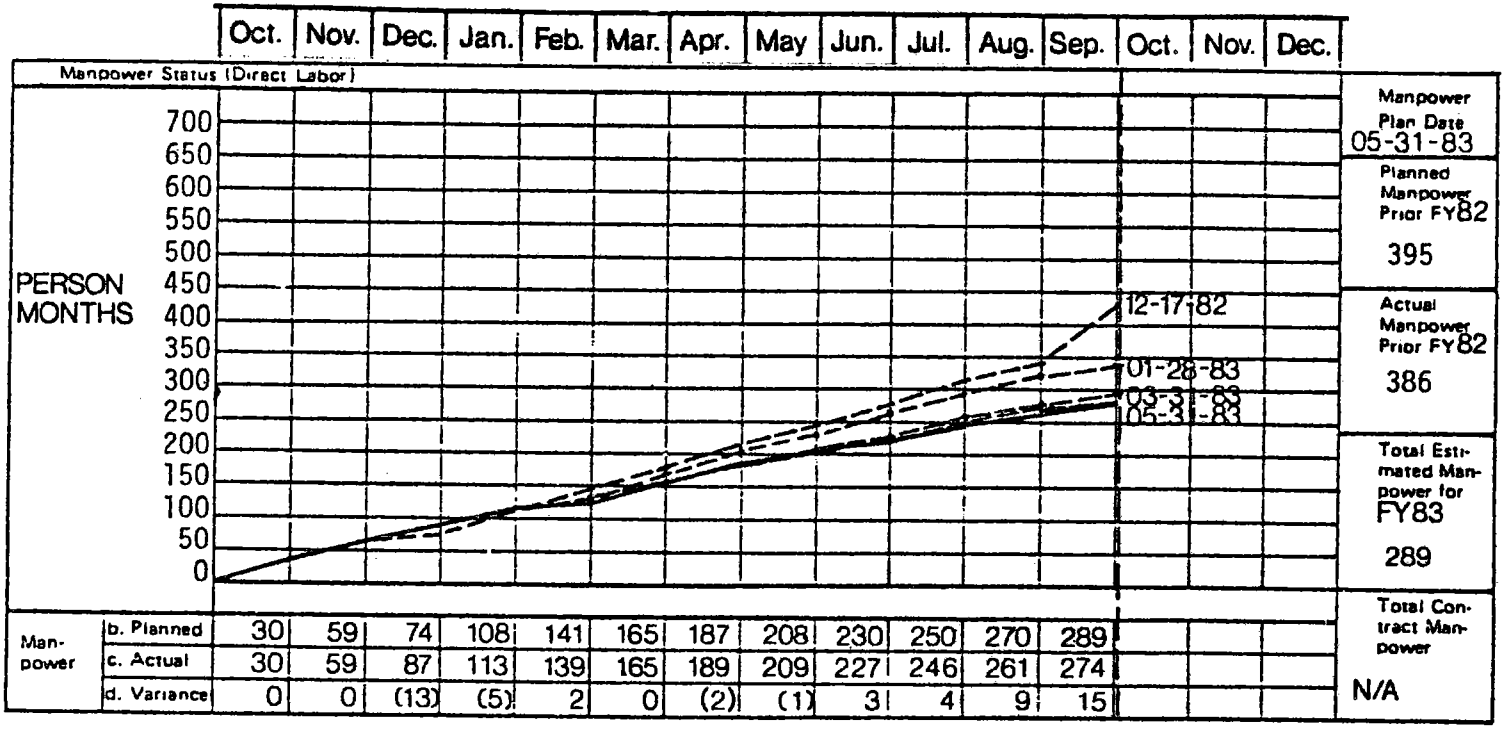
RESOURCE EXPENDITURE

Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute **1617 Cole Boulevard** **Golden, Colorado 80401**	From: 10/01/82 To: 9/30/83
3. Program Identification: SOLAR THERMAL TECHNOLOGY	
4. WPA/Task: PROGRAM TOTAL	



MANPOWER STATUS



		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Man-power	b. Planned	30	59	74	108	141	165	187	208	230	250	270	289			
	c. Actual	30	59	87	113	139	165	189	209	227	246	261	274			
	d. Variance	0	0	(13)	(5)	2	0	(2)	(1)	3	4	9	15			

Manpower Plan Date
05-31-83

Planned Manpower Prior FY82
395

Actual Manpower Prior FY82
386

Total Estimated Manpower for FY83
289

Total Contract Manpower
N/A

Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute **1617 Cole Boulevard** **Golden, Colorado 80401**	From: 10/01/82 To: 9/30/83

3. Program Identification: SOLAR THERMAL TECHNOLOGY

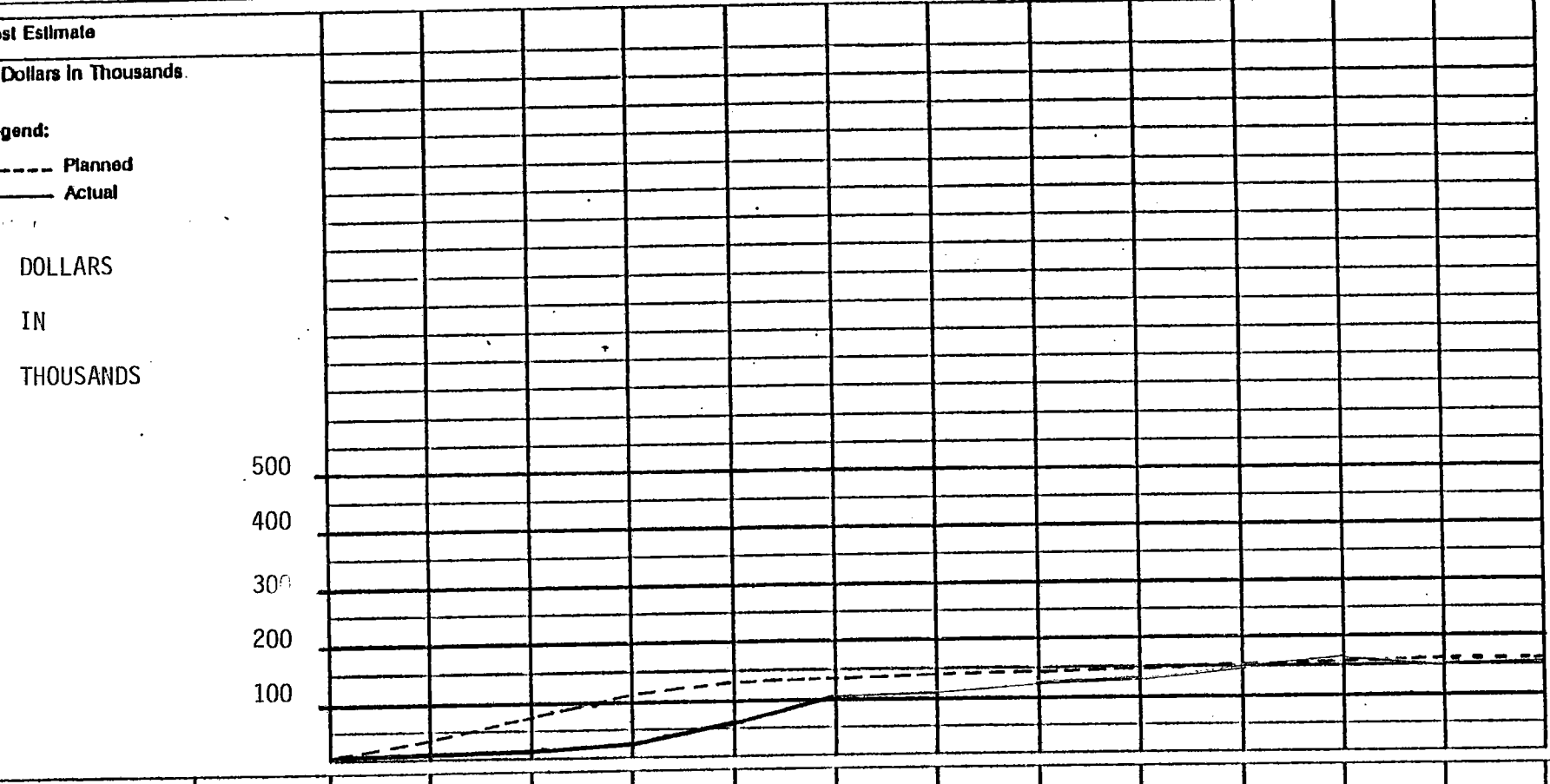
4. WPA/Task: 401 / ADVANCED RESEARCH

5. Months	O	N	D	J	F	M	A	M	J	J	A	S

6. Cost Estimate

a. Dollars in Thousands

Legend:
- ----- Planned
- ——— Actual



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	31	72	117	127	134	142	146	150	154	157	159	159	b. Planned
	c. Actual	5	17	43	65	107	109	126	138	154	163	152	152	c. Actual
	d. Variance	26	55	74	62	27	33	20	12	-	-6	7	7	d. Variance

Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/01/82 To: 9/30/83

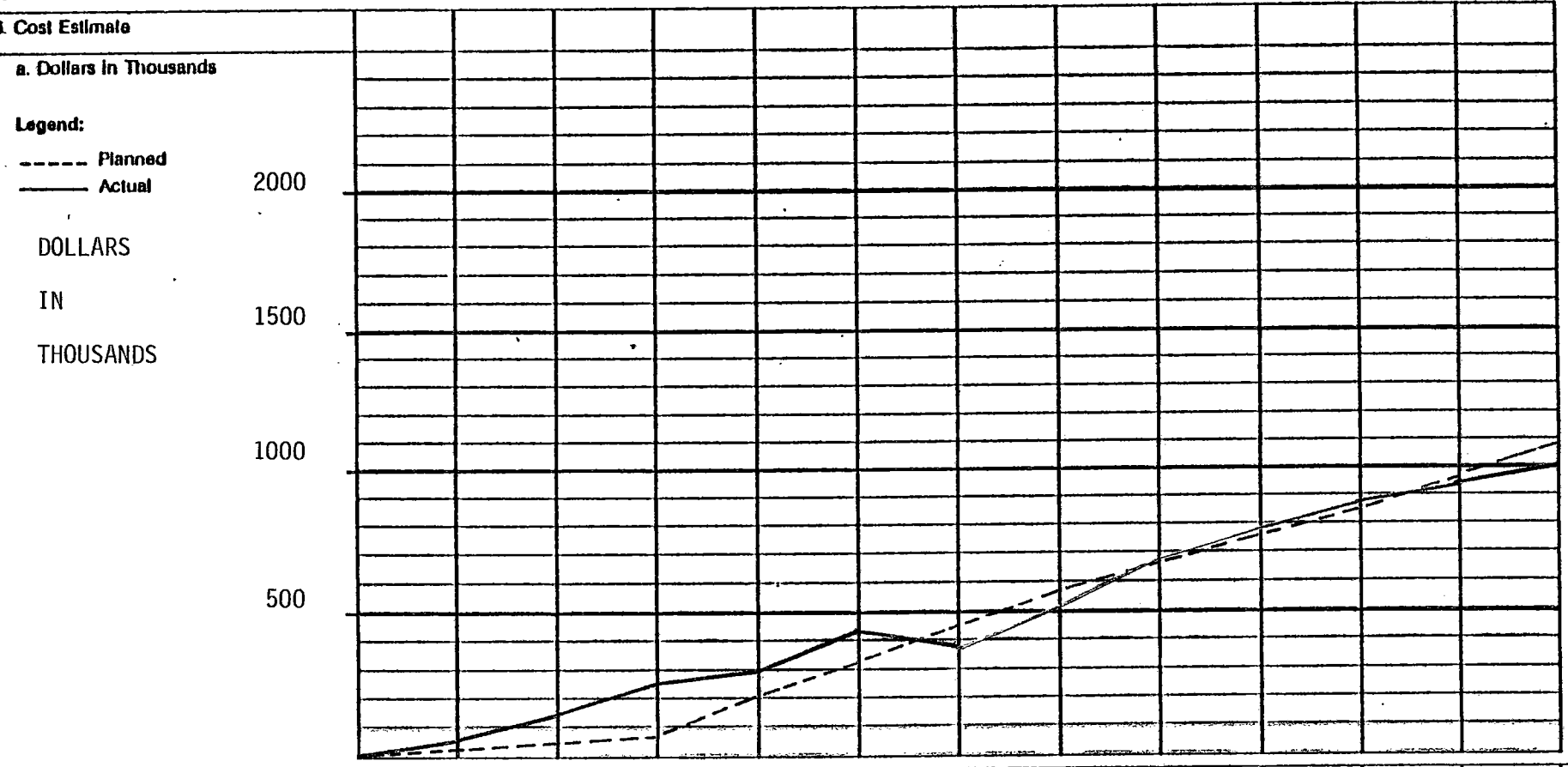
3. Program Identification: SOLAR THERMAL TECHNOLOGY

4. WPA/Task: 416 / Concentrator Advanced Development

5. Months	O	N	D	J	F	M	A	M	J	J	A	S

6. Cost Estimate

a. Dollars in Thousands



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	22	45	77	204	330	435	549	651	753	854	971	1088	b. Planned
	c. Actual	45	137	245	295	443	395	524	694	795	888	947	1002	c. Actual
	d. Variance	-23	-92	-168	-91	-113	40	25	-43	-42	-34	24	86	d. Variance

Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/01/82 To: 9/30/83

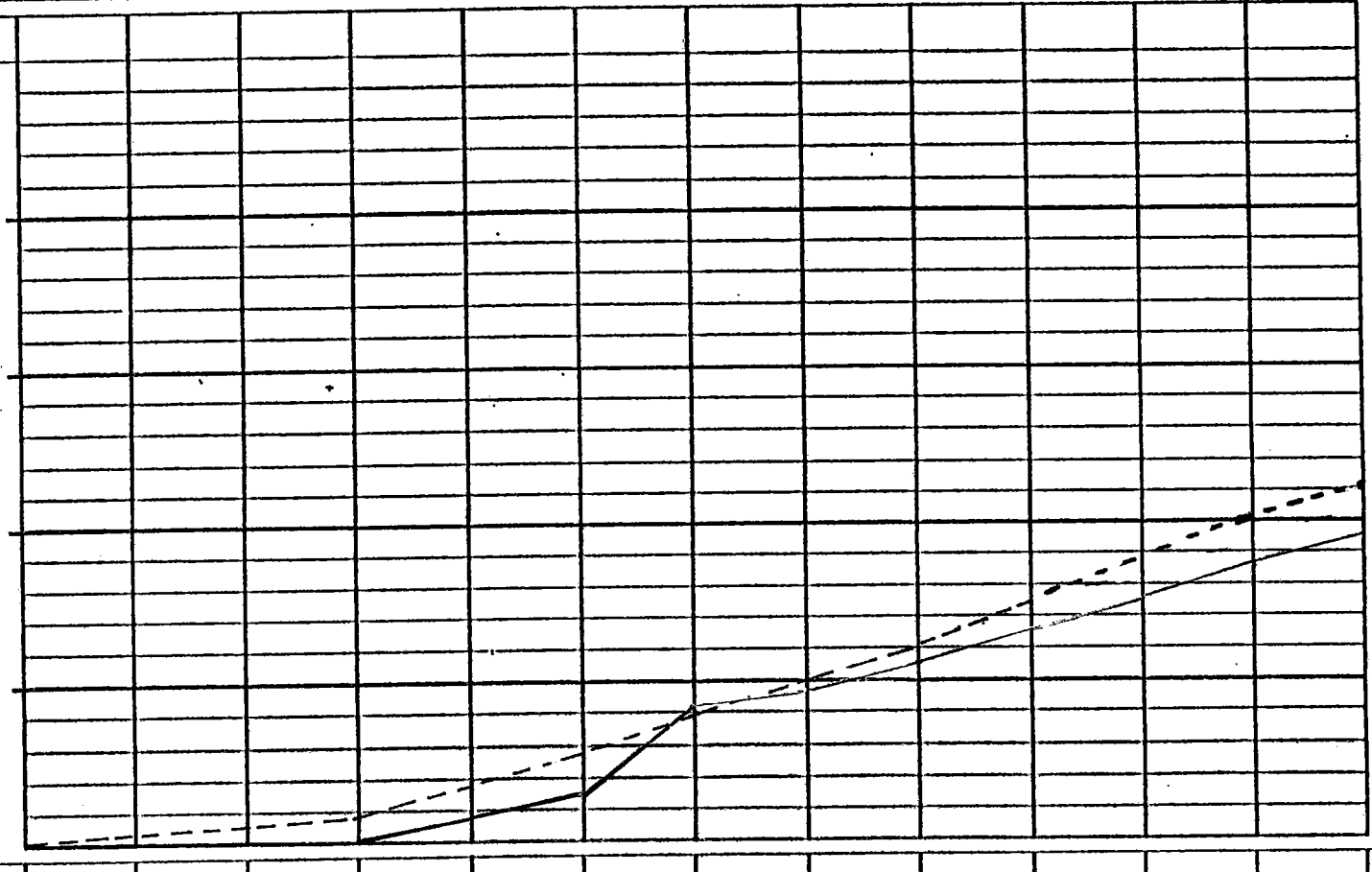
3. Program Identification: SOLAR THERMAL TECHNOLOGY

4. WPA/Task: 417 / Thermal Materials Research

5. Months	O	N	D	J	F	M	A	M	J	J	A	S

6. Cost Estimate

a. Dollars in Thousands



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	24	53	81	176	279	414	526	644	768	886	1003	1101	b. Planned
	c. Actual	-	-	-	88	155	430	491	565	667	787	874	964	c. Actual
	d. Variance	24	53	81	88	124	-16	35	79	101	99	129	137	d. Variance

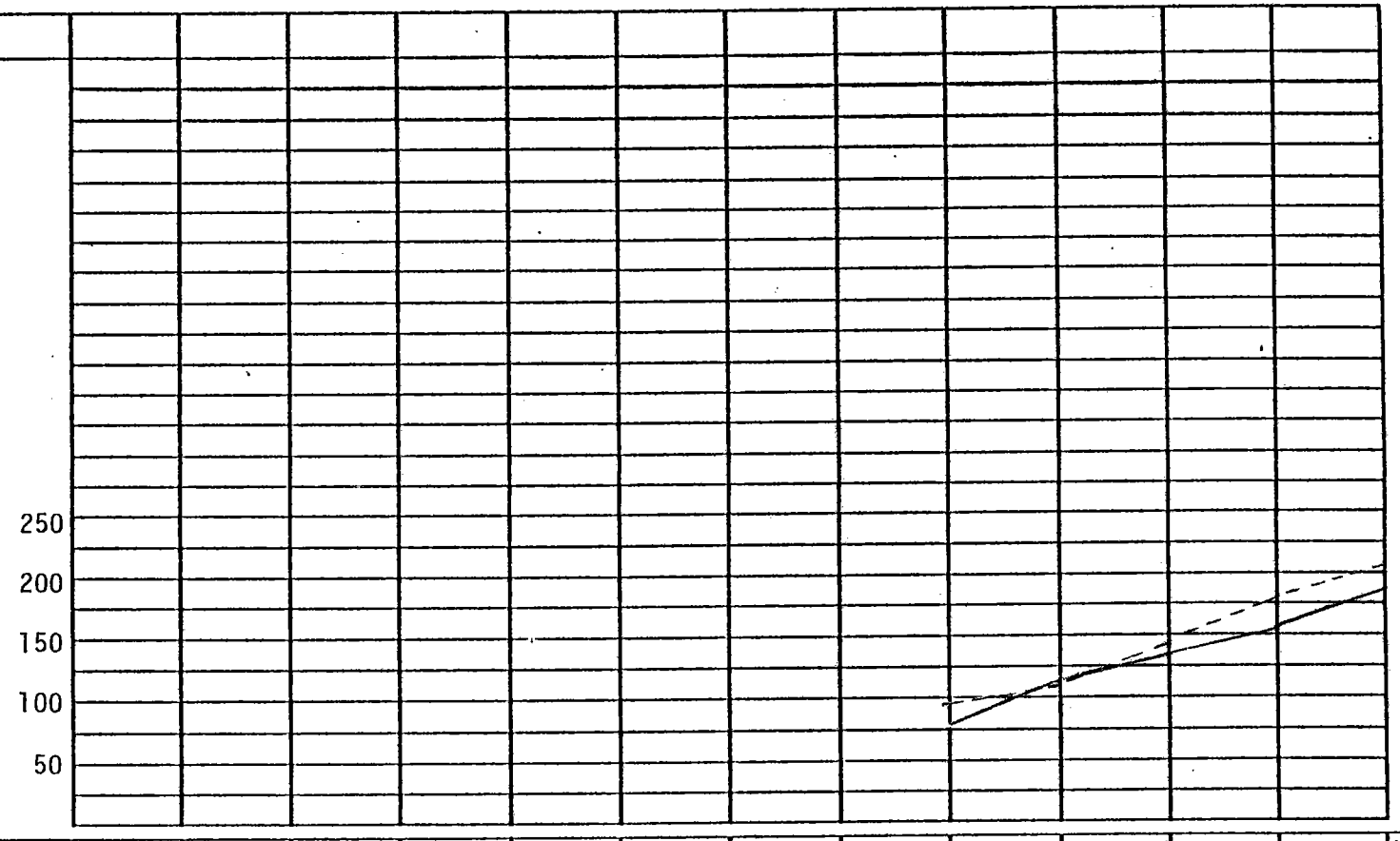
Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute **1617 Cole Boulevard** **Golden, Colorado 80401**	From: 10/01/82 To: 9/30/83

3. Program Identification: SOLAR THERMAL TECHNOLOGY

4. WPA/Task: 440 / SUPPORT TO SYSTEMS EVALUATION

5. Months	O	N	D	J	F	M	A	M	J	J	A	S
6. Cost Estimate												
a. Dollars in Thousands												
Accrued Costs — b. Planned								77	111	145	179	215
c. Actual								96	117	139	156	185
d. Variance								-19	-6	6	23	30



Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/01/82 To: 9/30/83

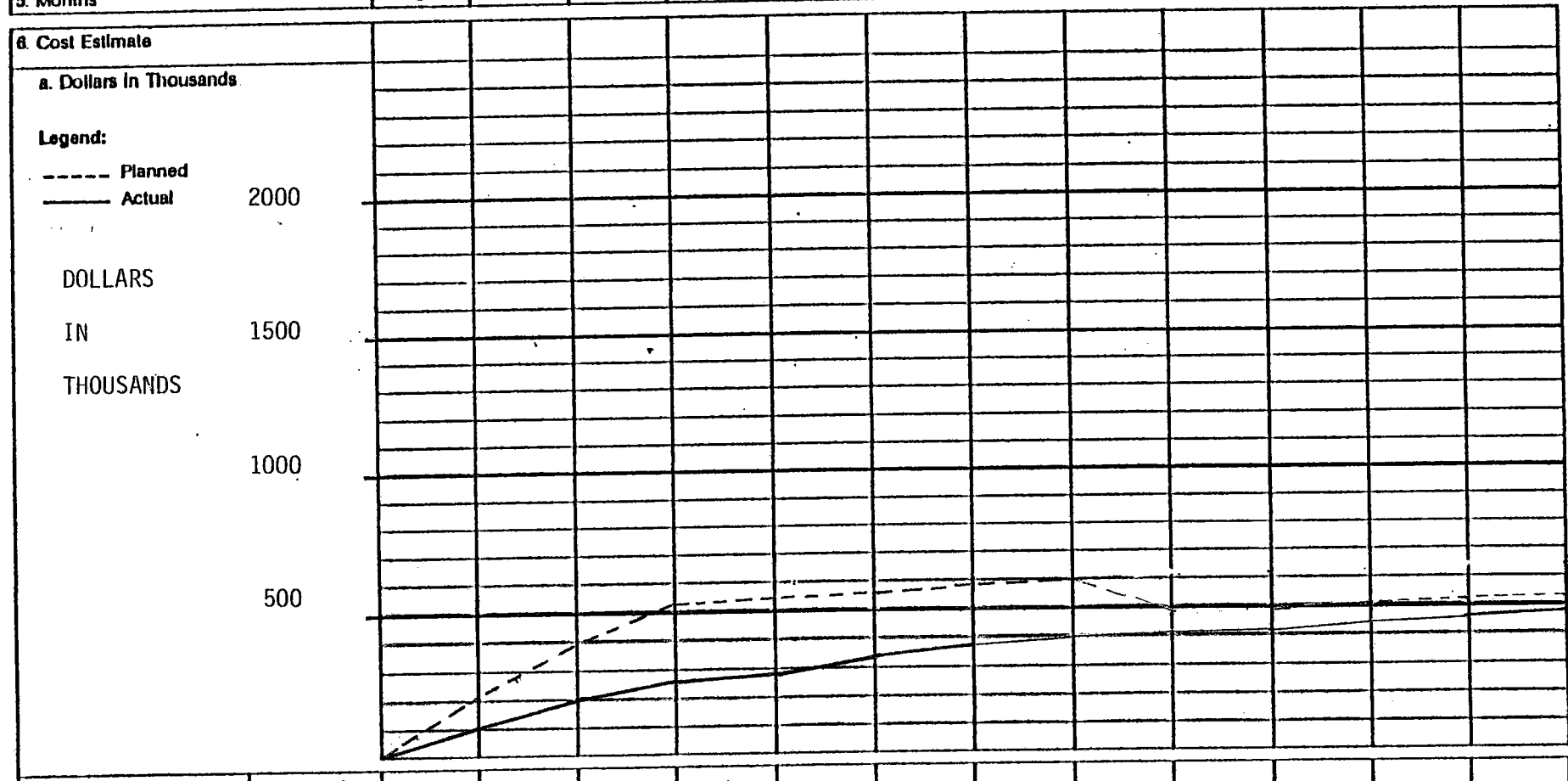
3. Program Identification: SOLAR THERMAL TECHNOLOGY

4. WPA/Task: 279 / APPLIED RESEARCH

5. Months	O	N	D	J	F	M	A	M	J	J	A	S

6. Cost Estimate

a. Dollars in Thousands



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	210	398	530	543	565	610	618	482	495	508	521	534	b. Planned
	c. Actual	108	201	262	282	330	375	400	404	427	447	469	491	c. Actual
	d. Variance	102	197	268	261	235	235	218	78	68	61	52	43	d. Variance

Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute **1617 Cole Boulevard** **Golden, Colorado 80401**	From: 10/01/82 To: 9/30/83
3. Program Identification: SOLAR THERMAL TECHNOLOGY	
4. WPA/Task: 280 / PROGRAM PLANNING AND COORDINATION	

5. Months	O	N	D	J	F	M	A	M	J	J	A	S
6. Cost Estimate												
a. Dollars in Thousands												
Legend: ----- Planned ——— Actual												
1500												
DOLLARS IN THOUSANDS												
1000												
500												
250												
Accrued Costs — b. Planned	25	47	64	64	64	64	64	64	64	64	64	64
c. Actual	29	46	50	46	53	52	54	54	54	54	54	64
d. Variance	-4	1	14	18	11	12	10	10	10	10	10	-

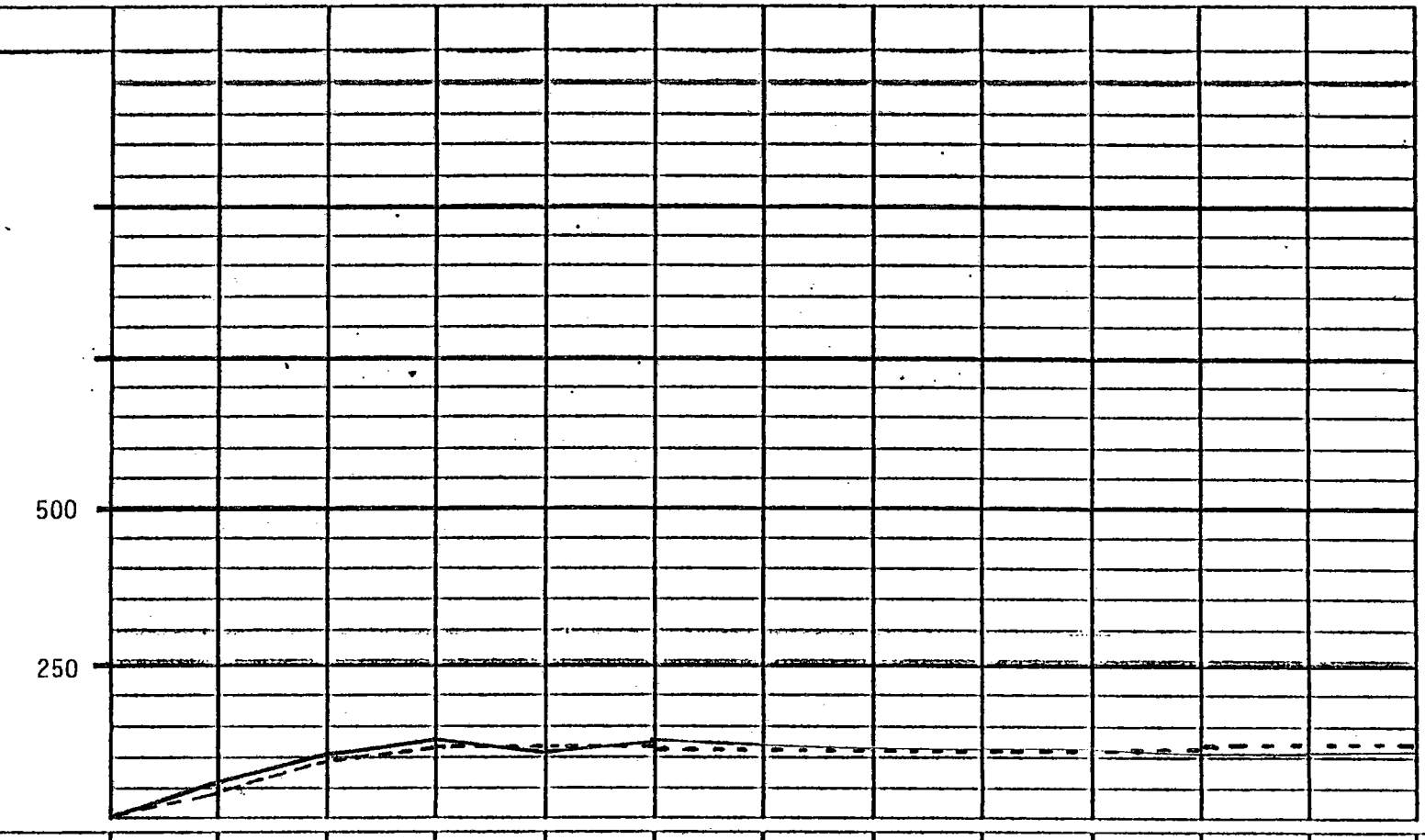
Budget Status

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/01/82 To: 9/30/83

3. Program Identification: SOLAR THERMAL TECHNOLOGY

4. WPA/Task: 281 / RESEARCH AND ADVANCED DEVELOPMENT

5. Months	O	N	D	J	F	M	A	M	J	J	A	S
6. Cost Estimate												
a. Dollars in Thousands												
Accrued Costs — b. Planned	44	89	119	119	119	119	119	119	119	119	119	119
c. Actual	54	107	123	116	124	121	122	126	128	107	109	109
d. Variance	-10	-18	-4	3	-5	-2	-3	-7	-9	12	10	10



SERI

SOLAR THERMAL ENERGY PROGRAM

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Reports Completed

Heat and Mass Exchange in Solar Ponds: Results of Preliminary Laboratory Tests.

"Performance Benefits of the Direct Generation of Steam in Line-Focus Solar Collectors." Journal of Solar Energy Engineering. K. May and M. Murphy (SERI).

SERI/SP-253-1790. Recommended Subelement Cost Goals for Advanced Generation Heliostats (SERI).

SERI/SP-253-1791. A Systems Study of the Polymer/Enclosed Heliostat Concept and a Comparison with Glass/Metal Heliostats (SERI).

SERI/TR-255-1641. Surface Analysis of Commercially Made Mirrors. Appl. Surf. Sc: 15 (1983) 75. T. M. Thomas, J. R. Pitts, and A. W. Czanderna, (SERI).

Decomposition of Sulphuric Acid in Hydrogen Production Test Equipment-Final Report (General Atomic).

SERI/TR-253-1818. Technical and Cost Benefits of Lightweight Stretched Membrane Heliostats. L. M. Murphy (SERI).

SERI/TR-255-1504. Matrix Approach for Testing Mirrors—Part 1, April, 1983. K. D. Masterson and M. A. Lind (SERI).

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SERI/TP-255-2054. Polymer Degradation on Reflecting Metal Films: Fourier Transform Infrared (FTIR) Reflection—Absorbance Studies. J. D. Webb, P. Schissel, T. M. Thomas, J. R. Pitts, and A. W. Czandera (SERI).

SERI/TR-251-1573. Research and Development Project Evaluation and Selection Methods for the Solar Thermal Technology Program. F. Krawiec (SERI).

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SERI/TP-253-1830. A Detailed Design Procedure for Solar Industrial Process Heat Systems: Overview. C. F. Kutscher (SERI).

SERI/TP-253-1839. Development of a Consensus Standard for Determining Thermal Performance of High Concentration Ratio Solar Collectors. J. B. Blackmon and M. C. Linskens and K. A. Reed.

SERI/TP-253-1831. The Development of SOLIPH—A Detailed Computer Model of Solar Industrial Process Heat Systems. C. F. Kutscher (SERI).

SERI/TP-253-1870. Direct Steam Generation in Line-Focus Solar Collectors. E. K. May and L. M. Murphy (SERI).

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SERI/TP-255-1586. Surface Analysis and Solar Energy Materials. A. W. Czanderna (SERI).

SERI/TP-255-1916. A Computer-Assisted Technique for Measuring K_T-V Relationships. R. T. Coyle and M. L. Buhl.

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"Solar Thermal Research and Development Methods." Journal of Research Management. F. Krawiec (SERI).

Draft Reports Completed for DOE Internal Use

Solar Ponds Multiyear Research Plan. R. Hewett (SERI).

Solar Thermal Research Multiyear Program Plan. R. Hewett (SERI).

Reports in Process

RESEARCH AND ADVANCED DEVELOPMENT - WPA 281A

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SERI/TR-255-988. Directory of Optical Measurement Requirements, Nomenclature, and Facilities for Solar Optical Materials Characterization. K. Masterson, J. McFadden (SERI).

Thermal and Optical Performance of Solar Steam, Inc., Deep Dish Concentrating Collector. K. Masterson, H. Gaul (SERI).

Structural and Mechanical Design Considerations for Stretched Membrane Heliostats. L. M. Murphy (SERI).

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SERI/TR-256-1488. Response Time Testing of Concentrators. A. Lewandowski (SERI).

THERMAL MATERIALS RESEARCH - WPA 417A

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