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ORNL/TM-5795

Low-Temperature Thermal Energy Storage Quarterly Progress Report for Period July–September 1976

H. W. Hoffman
R. J. Kedl

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy $4.00; Microfiche $3.00

ORNL/TM-5795

Contract No. W-7405-eng-26

Engineering Technology Division

LOW-TEMPERATURE THERMAL ENERGY STORAGE
QUARTERLY PROGRESS REPORT
FOR PERIOD JULY-SEPTEMBER 1976

H. W. Hoffman and R. J. Kedl

Date Published - February 1977

Manuscript Completed - January 31, 1977

NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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SUMMARY

This document is the second in a series of quarterly progress reports covering activities funded at ORNL by the ERDA Division of Energy Storage Systems to develop low-temperature thermal energy storage (TES) technology. These systems will be based on either sensible or latent heat storage at temperatures up to ∿250°C.

At ORNL, research efforts were continued to (a) develop a time-dependent analytical model that will describe a TES system charged with a phase-change material, (b) measure thermophysical properties and melt-freeze cyclic behavior of interesting PCM's, and (c) determine crystal lattice structures of hydrated salts and their nucleators. A report on TES subsystems for application to solar energy sources was completed and is being reviewed.

In the area of program management, subcontracts were signed with Clemson University, Dow Chemical Company, Suntek Research Associates, and The Franklin Institute. Detailed reviews were completed for ten unsolicited proposals related to TES. Industries, research institutions, universities, and other national laboratory participation in the TES program, and for which ORNL has management responsibilities, are listed.

LOW-TEMPERATURE THERMAL ENERGY STORAGE
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H. W. Hoffman and R. J. Kedl

1. INTRODUCTION

The Thermal and Chemical Storage (T/CS) Branch of the ERDA Division of Energy Storage Systems (ESS) has responsibility for developing the technology on thermal energy storage relevant to the utilization of energy from solar and waste heat sources. In turn, T/CS has delegated to ORNL responsibility for managing that portion of their program dealing with thermal storage by sensible or latent heat techniques at temperatures to ∿250°C. This document — the second in a continuing series[1] — reports on activities within this charter during the fiscal transition quarter (July-September 1976).

Early in this quarter, the ERDA TES effort was restructured. This resulted in a change in designation for this portion of the program from "TES for Building Heating and Cooling Applications" to "Low-Temperature TES." In the process, the program scope was broadened to include technology development for all applications of low-temperature TES; thus, in addition to building heating and cooling, program elements cover agricultural and industrial uses, the special case of aquifer storage, systems studies relevant to TES utilization, and off-peak electrical power.

This progress report describes the technical studies on-going at ORNL, as well as the administrative status of subcontracts for which we now have management responsibility. Since reporting procedures on subcontracts were not in place by the end of this period, technical progress by the subcontractors has been omitted; this information will appear in future reports.

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[1]TES for Building Heating and Cooling Applications, Quarterly Progress Report for Period April-June 1976, ORNL Report TM-5700, Oak Ridge National Laboratory, November 1976.

2. PROGRAM OBJECTIVE

The Low-Temperature Thermal Energy Storage (LTTES) program is directed to the development of sensible and latent heat storage technologies capable of accepting and discharging thermal energy effectively at temperatures up to ∿250°C. [Storage at higher temperatures and by reversible chemical reaction are the responsibility of NASA-Lewis Research Center and Sandia Laboratories-Livermore, respectively.] This objective is consistent with the National TES Program and supports specific goals relevant to building heating and cooling and industrial/agricultural applications utilizing solar, off-peak electrical, and waste heat energy sources.

Program objectives are pursued within the general guideline that supporting research and technology (overlapping the ERDA categorical designations of applied research and technology development) will be within the province of research institutes, universities, and national laboratories and concept development (overlapping technology development and engineering development) of industrial participants.

3. ORNL TECHNICAL STUDIES

3.1 Mathematical and Physical Modeling (L. Jung and A. Solomon)

Development of a time-dependent analytical model describing the melting-freezing process of a TES system charged with PCM's was continued this quarter at a low level of effort. Emphasis was on extraction of an approximate solution from the defining differential equations for the time of melting of PCM in cylinderical coordinates. The purpose of this exercise is to correlate melting times of wax in test tubes when immersed in a water bath (see Section 3.3) and, consequently, to determine if any significant observations or conclusions may be drawn from this simplified approach. The model does not include either natural thermal convection efforts in the molten PCM or finite container-wall thickness. It also assumes a large Nusselt modulus outside the tube (i.e., high heat transfer coefficient).

Using the heat balance integral method, both constant and linear approximations of the temperature distribution were used to obtain total melting times, τ, for the cylinder. The constant case conferred well with an empirical relationship:

$$\tau = a\, D^n/\Delta T \ ,$$

where a and n are constants, D is the diameter, and ΔT is the temperature difference between the circulating fluid and the PCM melting point. The linear temperature approximation yielded a relationship:

$$\tau = (D^2/4\alpha)\ (7/18 + H/6C\Delta T) \ ,$$

where α is the thermal diffusivity, H is the latent heat of fusion, and C is the heat capacity of the PCM. This relationship overestimated the measured melting times of wax in a test tube by a factor of 1.2-1.7 for the three smallest tubes and 2.4-2.8 for the largest tube.

3.2 Subsystems for Solar Application (C. L. Segaser)

The report defined under this task (see Quarterly Progress Report for Period April-June 1976, ORNL Report TM-5700) has been completed and is under review.

3.3 Thermodynamic Properties and Interactions (S. Cantor)

Much of our effort during this period was devoted to studying the thermophysical behavior of waxes. In particular, we concentrated on Quaker State IP-2 Slack Wax and a Pennzoil product; both are paraffin waxes with melting temperatures in the same range.

The enthalpy of fusion of the Quaker State wax, as measured with a differential scanning calorimeter (DSC), was determined to be 25.4 cal/g. In test-tube scale experiments, it was observed that the wax still melted completely to a clear liquid over a rather narrow temperature span (45-49°C) after 50 melt-freeze cycles and that freezing occurred without supercooling. The viscosity of the melt, as measured with a Brookfield instrument, was found to be 13 and 7 cp at 50 and 60°C, respectively. It is presumed that waxes are Newtonian fluids; nevertheless, viscosities should be considered tentative until this is established.

A serious problem in the use of waxes as TES media is their low thermal conductivity. The effect of k was examined in a preliminary fashion by recording the time to complete melting of wax samples contained in test tubes under a variety of conditions: differing tube diameters, tube orientations, and heat-source temperatures (a circulating water bath). One interesting observation was that immersion of steel wool in the wax specimen reduced the melting time from 30 minutes down to 20 minutes under similar conditions. A loose roll of corrugated aluminum was more effective, reducing the time for the particular sample by 44% (from 45 min down to 25 min).

Information supplied by Pennzoil states that the product we tested has an enthalpy of fusion of 43.9 cal/g and a melting range of 42-49°C. Note the considerably higher enthalpy of fusion compared to the Quaker State wax. The kinematic viscosity of Pennzoil wax has been measured with a capilliary flow viscometer (Ubbelohde suspended level type) that was calibrated with water. Data are as follows:

Temperature (°C)	Kinematic Viscosity (centistokes)	Dynamic Viscosity (centipoises)
49.0	6.30	4.91
51.9	5.97	4.66
57.6	5.30	4.13
59.95	4.96	3.87

The dynamic viscosity was calculated by multiplying the kinematic viscosity by the density of the wax (0.78 g/cm^3).

Times to complete melting were also measured for the Pennzoil wax by four samples of different volumes (10, 25, 50, 500 ml) but equal depth, simultaneously immersing in water baths fixed at 120, 125, and 130°F. The twelve experimental results fit the empirical equation

$$\tau = d\ D^n/\Delta T$$

(see Section 3.1).

To support thermal analysis efforts, a qualitative experiment was performed to determine if natural thermal convection is a mechanism involved in the radial transport of heat through a wax melt. Small graphite particles were added to one of the test tubes of wax. When the wax was carried through a melting cycle, motion of these particles could be observed. It was apparent that thermal convection loops were present in the melt. Measurement of the heat transfer coefficient between the pyrex cylinder and the water bath is planned. This will be accomplished with a metal tube instrumented with thermocouples and an internal resistance heater.

Freeze-melt cycles were examined for sodium thiosulfate pentahydrate, $Na_2S_2O_3 \cdot 5H_2O$, using the differential scanning calorimeter. The salt hydrate supercooled in each of six heating and cooling cycles; in two cycles the enthalpy recorded on melting was about 25% greater than the enthalpy recorded for crystallization. The DSC results agreed with the generally reported incongruent melting and supercooling characteristic of this material.

3.4 Crystalline Structures (W. R. Busing)

Salt hydrates are a class of chemicals with high potential for the storage of thermal energy. However, these materials are characterized by unpredictable nucleating and crystalline behavior. In order to better understand these phenomena, it is important to establish the crystalline structures of hydrates, including the coordinates and thermal motion parameters for hydrogen and the other atomic constituents of the salts.

Previous work by Ruben, et al.[2] on $Na_2SO_4 \cdot 10H_2O$ by X-ray diffraction did not establish hydrogen atom locations. We have now measured 2636 neutron diffraction intensities for this compound and have refined the crystal structure to within a discrepancy factor of 10.2%. The experimental hydrogen positions agree qualitatively with those postulated by Ruben, et al. and show a disorder that satifactorily explains the residual entropy observed by others.[3,4] The sulfate ion is surrounded by water molecules, and each of its four oxygen atoms is an acceptor for three hydrogen bonds. A large apparent thermal motion of three of these oxygen atoms has now been interpreted as a rotational disordering of the sulfate ion between two positions which have occupancy factors of 0.70 and 0.30. In shifting from one position to the other, each of the three oxygen atoms breaks one hydrogen bond and forms a different one.

Borax, $Na_2B_4O_7 \cdot 10H_2O$, is known to be a nucleating agent for Glauber's salt. It is important, therefore, to define its crystal structure, so that the parameters relevant to the nucleation induction process can be identified. The approximate structure of Borax was determined by Morimoto[5] through X-ray diffraction, but again the hydrogen

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[2] H. W. Ruben, D. H. Templeton, R. D. Rossenstein, and I. Olovsson, J. Amer. Chem. Soc., 83, 820 (1961).

[3] K. S. Pitzer and L. V. Coulter, J. Amer. Chem. Soc., 60, 1310 (1938).

[4] G. Brodale and W. F. Grauque, J. Amer. Chem. Soc., 80, 2042 (1958).

[5] N. Morimoto, Mineral J. (Sapporo), 2, 1 (1956).

atoms were not located. We have now defined the complete structure to within a discrepancy factor of 6.0%, based on 2373 experimental neutron diffraction intensities. We have confirmed Morimoto's proposal that the anion structure is best represented by the formula $Na_2B_4O_5 \cdot (OH)_4 \cdot 8H_2O$. There appears to be no disorder in the structure.

Chains of hydrated cations $(Na_2 \cdot 8H_2O)_n^{2+}$ that are found in both the Glauber's salt and borax structures show a remarkable similarity, even in the positions of the hydrogen ions. Very likely, this similarity is one of the reasons that borax effectively nucleates Glauber's salt.

Another potential working material, $Na_2S_2O_3 \cdot 5H_2O$, has also been studied by neutron diffraction;[6] however, only 350 intensities were measured in three axial zones. We have not completed a neutron diffraction data collection in which 2108 intensities were measured; results are being analyzed.

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[6]V. M. Padmanabhan, et al., Acta Cryst., B27, 253 (1971).

4. SUBCONTRACT PARTICIPATION

Current participation through subcontracts of industries, universities, research institutes, and other national laboratories as a part of the LTTES technology development effort is as listed in Table 76-9.1. During this quarter, program content and direction were reviewed with Monsanto Research Corporation and Suntek Research Associates; similar discussions will be held with the other contractors in the next quarter.

A summary description of each subcontract is given in Table 76-9.2; succeeding quarterly reports will discuss pertinent results obtained by each contractor.

Table 76-9.1 LTTES Program Participants

Industries	Subject
Dow Chemical Company	Macro-encapsulation of PCM's
Lockheed Missile & Space Company	Use of Desiccants in Solar Crop Drying
Monsanto Research Corporation	Form-Stable Polyethylene for TES
Suntek Research Associates	Building Materials Containing PCM's
Universities	
Auburn University	TES in Aquifers
Clemson University	Immiscible Fluid TES Concept
George Washington University	Long-Duration Earth TES
Pennsylvania State University	Sensible TES in Solids
University of Delaware	TES with Hydrated Salts
Research Institutions	
Desert Research Institute	TES with Controlled Nucleation
The Franklin Institute	TES by Heat of Solution
National Laboratories	
Argonne National Laboratory	Economics of Load Leveling
Brookhaven National Laboratory	Energy Management in Buildings
Oak Ridge National Laboratory	PCM Freeze-Melt Cycle Behavior; Salt Hydrate Crystalline Structures; Moving-Boundary Heat Transfer Problem

Table 76-9.2 Description of Current LTTES Program Subcontracts

INDUSTRIES

1. Dow Chemical Company

   Purpose: Develop PCM macro-encapsulation technology for the heating application

   Key Anticipated Result: Sub-scale laboratory demonstration of concept involving a few thousand Btu; preliminary design of residential TES subsystem for the solar heating application

   Current Status: Just started

   Term: September 7, 1976-March 6, 1978

2. Lockheed Missiles and Space Company

   Purpose: Develop a preliminary design of a regenerative desiccant crop-drying facility

   Key Anticipated Result: Demonstrate a laboratory-scale heat recovery and desiccant regenerative system

   Current Status: Laboratory unit, using LiCl aqueous solution as the desiccant, has been assembled; check-out and initial runs are underway

   Term: August 1, 1976-February 28, 1977

3. Monsanto Research Corporation

   Purpose: Develop "form-stable," cross-linked polyethylene as a TES material for the heating/cooling application. Cross-linking would be just sufficient to impart shape-holding characteristics to the polymer as it melts, yet not detract significantly from the heat of fusion of the crystalline polyethylene before cross-linking

   Key Anticipated Result: A laboratory demonstration of the PCM media; about five lbs of cross-linked polyethylene will be freeze-melt cycled 1000 times

   Current Status: Screening of crystalline polyethylene raw materials, cross-linking agents, and thermal pretreatment processes largely completed; thermal cycling apparatus completed

   Term: July 1, 1976-April 30, 1977

Table 76-9.2 Description of Current LTTES Program Subcontracts (Cont'd.)

INDUSTRIES

4. Potomac Electric Power Company

Purpose: Evaluate the potential impact of off-peak electricity use on the utility demand load

Key Anticipated Result: A demonstration home utilizing TES with solar energy assist, directed towards the heating/cooling and domestic hot-water applications

Current Status: Equipment has been installed in a demonstration home

Term:

5. Suntek Research Associates

Purpose: Develop the technology of filling low-density concrete blocks with PCM's, thus building structural components will have the capability of storing energy

Key Anticipated Results: Hand-made blocks of undefined shape will be filled with PCM's and sealed and exposed to 1000 freeze-melt cycles; thermal and mechanical properties measured before, during, and after cycling

Current Status: Brick-sized blocks have been filled and sealed; thermal cycling is underway

Term: August 15, 1976-February 14, 1977

UNIVERSITIES

6. Auburn University

Purpose: Evaluate hydraulic and thermal parameters in a test aquifer by comparison with analytical predictions; thus, the analytical models may be made more realistic and may then be used to explore storage strategies in aquifers

Key Anticipated Result: To inject, store, and withdraw a sufficient quantity of warm water (condenser cooling water from a power plant) to evaluate the necessary hydraulic and thermal parameters

Current Status: Warm-water injection, storage, and withdrawal has been completed. The injection was terminated prematurely because fines in the water resulted in plugging of the aquifer; data obtained is believed to be adequate to accomplish the above purpose

Term: November 15, 1975-December 31, 1976

Table 76-9.2 Description of Current LTTES Program Subcontracts (Cont'd.)

UNIVERSITIES

7. Clemson University

Purpose: Develop immiscible-fluid, direct-contact heat transfer TES concept, where one of the phases is a hydrated salt

Key Anticipated Result: An engineering laboratory experiment (50-100 gal) to identify and evaluate factors affecting system performance (e.g., carry-over, thermal efficiency, etc.)

Current Status: Bench-scale scoping experiments completed; selection of material combinations underway

Term: June 1, 1976-May 31, 1978

8. George Washington University

Purpose: Develop the concept of long-term storage of energy (as sensible) in the earth

Key Anticipated Result: Thermal analysis and evaluation of the concept, including means of heat injection and recovery; development of an appropriate heat pipe

Current Status: Thermal analysis studies largely completed; laboratory studies with the heat pipe are underway

Term: July 1, 1976-December 1976 (no cost extension to March 31, 1977)

9. Pennsylvania State University

Purpose: Develop an analytical model to describe the transient thermal behavior of a solid, sensible TES unit; model will be used for design optimization studies

Key Anticipated Result: To develop the analytical model; verify it in the laboratory; and accomplish the design optimization studies

Current Status: Development of the computer program has been completed; experimental verification and design optimization studies are underway

Term: June 1976-July 1, 1977 (no cost extension to December 31, 1977)

10. University of Delaware

Purpose: Document prior work on TES media and conduct additional laboratory studies

Key Anticipated Result: To accomplish the above

Current Status: Documentation underway; heat transfer loop for thermal cycling Glauber's salt has been built;

Table 76-9.2 Description of Current LTTES Program Subcontracts (Cont'd.)

UNIVERSITIES

10. University of Delaware

Current Status: Coaxial cylinderical thermal conductivity cell has been built and is being calibrated; crystal growth studies are underway

Term:

RESEARCH INSTITUTES

11. Desert Research Institute

Purpose: Develop techniques to nucleate PCM's (during heat recovery cycle) away from the heat transfer surface; thus, the solid will not adhere to the surface and act as a thermal resistance

Key Anticipated Result: Identification, laboratory demonstration, and evaluation of techniques to accomplish the above.

Current Status: Crystal growth studies in supercooled solutions of Glauber's salt have been completed; several nucleating techniques have been evaluated (e.g., ultrasonics, electric fields, and cold fingers); search for surface coatings that discourage nucleation on the heat transfer surface is getting underway

Term: July 1, 1975-June 30, 1977

12. The Franklin Institute

Purpose: Develop heat of solution TES concept (using saturated aqueous solutions) for storage of cool (40-60°F) and heat (120-180°F)

Key Anticipated Result: Laboratory demonstration ($\sim$25 gal) to identify and resolve problems associated with precipitate settling and movement

Current Status: Laboratory measurements of thermophysical properties completed; salts for each temperature range have been selected; design of demonstration loop is largely completed

Term: June 21, 1976-May 20, 1977

Table 76-9.2 Description of Current LTTES Program Subcontracts (Cont'd.)

NATIONAL LABORATORIES

13. Argonne National Laboratory

Purpose: Commercialization feasibility studies (economics) of TES applications

Key Anticipated Result: To complete these studies; develop strategies for commercialization; and make recommendations for R&D

Current Status: A study directed towards customer-side storage of off-peak electrical energy for the heating, air conditioning, and hot-water applications has been completed (final report under review); TES related to heat pumps, solar energy, and industrial process heat applications is getting underway

Term: One fiscal year basis

14. Brookhaven National Laboratory

Purpose: Energy management as applied to thermal conditioning of residences and commercial buildings; TES is one component of the broader study

Key Anticipated Result: Identification of TES subsystems that may be integrated into the overall residential thermal conditioning system and thus result in the conservation of energy

Current Status: Have identified fatty acids (PCM's) dispersed in concrete building materials as an appropriate TES component; thus, the building itself may have TES capability

Term: One fiscal year basis

5. PROGRAM MANAGEMENT

5.1 Subcontracts

Subcontracts were signed in this quarter with Clemson University, Dow Chemical Company, Suntek Research Associates, and The Franklin Institute (see Section 4).

5.2 Proposal Reviews

During this period 18 unsolicited proposals were either received or remained back-logged from the previous quarter. Detailed comments and recommendations were provided on ten of these; review remains incomplete on the eight others. These proposals are listed in Table 76-9.3.

5.3 Meetings and Visits

Program staff participated in the following meetings and visits during the July-September period.

a. TES Area Managers. H. W. Hoffman participated on July 27, 1976, at ERDA-Washington in the regular quarterly meeting of TES Program area managers. Significant results of the meeting pertainint to this program are as follows:

- The TES Program, originally categorized into eight applications areas, will now be consolidated into three systems development areas: low-temperature sensible and latent heat, high-temperature sensible and latent heat, and reversible thermochemical reactions. Management of these areas will be as follows:

  (1) Low-Temperature TES — Oak Ridge National Laboratory (H. W. Hoffman, Manager)

  (2) High-Temperature TES — NASA-Lewis Research Center (W. J. Masica, Manager)

  (3) Reversible Chemical Reaction TES and Heat Transport — Sandia Laboratories-Livermore (R. W. Mar, Manager)

- United States Geological Survey activities in aquifer TES will be coordinated through ORNL, with the two organizations cooperating on program planning.

Table 76-9.3 Unsolicited Proposals Reviewed, July-September 1976

	Submitting Organization	Title	Review Status
1.	Arthur D. Little, Inc.	A Natural Ice Storage System to Reduce Peak Air-Conditioning Loads	Complete: Letter to ERDA 9/30/76
2.	Bend Research, Inc.	Underground Storage of Solar Energy	In review
3.	Dow Chemical Company	Development of Thermal Storate Systems for Heating & Cooling of Residences (a) High-temperature storage for absorption air conditioners (b) Dispersed storage	Complete: Letter to ERDA 8/27/76
4.	General Electric Corporation	Phase-Change Thermal Energy Storage (Preproposal)	Review awaiting receipt of formal proposal
5.	General Energy Associates	Pressure Storage Systems to Reduce Peak Power Demand	Complete: Submitted orally to C. J. Swet (ERDA) 9/21/76
6.	Geoscience, Ltd.	Utilization of Thermal Storage Systems for Solar Energy Heating & Cooling at Residences	Complete: submitted orally to Company President 9/13/76
7.	Henry F. Miller	TES Applied to Mobile Refrigeration Industry	In review
8.	Honeywell, Inc.	Use of Urea-Based Eutectics to Store Thermal Energy	In review
9.	L'Garde, Inc.	A Study of Heat Sink Energy Barriers	In review
10.	Lockheed Missiles & Space Company	Development of Standardized Tests of Energy Storage Materials (ESM's) Performance	Complete: Letter to ERDA 7/29/76
11.	Oak Ridge National Laboratory	Thermal Energy Storage in High-Temperature Phase Transition Materials	Complete: Letter to ERDA 7/13/76
12.	Poseidon Research	Peak-Shaving and Energy Conservation Through a Novel Application of Thermal Energy Storage	Complete: Letter to ERDA 8/25/76
13.	PPG Industries	Thermal Transport Fluid Development	Sent to ORNL for information only; possible interest later

Table 76-9.3 Unsolicited Proposals Reviewed, July-September 1976 (Cont'd.)

	Submitting Organization	Title	Review Status
14.	RCA	Technology and Economic Feasibility of Thermal Storage for Solar Heating and Cooling Systems	Complete: Submitted orally to C. J. Swet (ERDA) 9/21/76
15.	Rocket Research Corporation	Utilization of Metallic Foams for Improved Heat Transfer in Phase-Change and Sensible-Heat Storage Devices	In review
16.	Standun, Inc.	The Use of Supercooled Fluids for Energy Storage in Solar Heating Applications	Complete: Letter to ERDA 7/14/76
17.	TRW	Modular Heat Pipe/Phase-Change Material Thermal Storage System	In review
18.	University of Arizona	Emulsion/Dispersion Solar Thermal Energy Storage System	Complete: Letter to ERDA 8/4/76

b. Division of Solar Energy (DSE)-Solar Cooling and Heating Branch Contractor's Meeting. H. W. Hoffman attended the final sessions on July 28 of a three-day meeting at Columbia, Maryland, at which contractors to the DES-Solar Cooling and Heating Branch reported on progress and plans. This meeting was organized into nine sessions: solar air-conditioning projects, controls projects, systems-analysis projects (3), solar collector projects (3), thermal storage/heat exchanger projects, and heat-pump projects. A total of 61 reports was presented.

Hoffman also participated on the afternoon of July 28 in the final review of the Solar H/C Branch's program plan. Somewhat earlier, Hoffman had been involved in technical discussions on the TES elements for the solar program (December 18-19, 1975, University of Virginia) and in evaluation of TES proposals for the solar program (February 26-27, 1976, NBS-Gaithersburg, Maryland).

c. Visit to Georgia Institute of Technology. On July 8, J. R. Engel and M. D. Silverman visited the Solar Energy Department of the Georgia Institute of Technology to discuss thermal energy storage in molten salts. Georgia Tech, under subcontract to Martin Marietta, is building an energy-storage research experiment in association with a proposed solar pilot plant at the Georgia Power Company Yates Plant; operation of the experiment in November 1976 is expected. Hitec will be used to desuperheat prime steam to collect heat for storage at $\sim$850°F. Current plans would store this energy in oil (probably EXXON Calona 43), but it is felt that the molten salt would lead to a system with better performance characteristics. Though the temperature range of this application is outside of the defined scope of the ORNL-managed portion of the TES national program, contact will be maintained because of other programmatic interests.

d. Aquifer TES. R. J. Kedl participated in a meeting on August 6 at the U.S. Geological Survey Headquarters (Reston, Virginia), where the Auburn University aquifer TES experiment was discussed. They have experienced plugging of the aquifer sand at the injection pipe discharge, which is located near the top of the aquifer. Although the injected water (obtained from the power plant discharge canal) is highly filtered, fines apparently still get through and are the cause of this plugging.

It was suggested by Auburn that instead of using water directly out of the canal, wells be drilled adjacent to the canal and hot water be obtained from the wells, thus relying on the earth to filter the canal water. All participants at the meeting agreed that this was a good idea, and Auburn will conduct an exploratory experiment to assess the suggestion.

e. Sharing the Sun Conference. R. J. Kedl attended the International Solar Energy Society (American Section) and Solar Energy Society of Canada-sponsored conference titled "Sharing the Sun: 76," held on August 15-20 in Winnipeg, Canada, where he served as chairman for the "Solar Heat Storage for Buildings" session.

f. Monsanto Research Corporation. R. J. Kedl visited the Monsanto Research Corporation in Dayton, Ohio, on August 26 as technical program monitor for their subcontract [Form-Stable Crystalline Polymer Pellets for Thermal Energy Storage (see Section 4)]. The general impression was that Monsanto personnel and facilities are quite capable of carrying out the proposed research.

g. Wax as a TES Material. On August 10 representatives of Pennzoil Company visited ORNL to discuss the physical and chemical properties of wax and its potential as a PCM for TES. One important point noted by Pennzoil was that a wax may be tailored to yield any desired average melting point (within certain limits).

h. Information Exchange Meeting. Hoffman and Kedl participated in the first annual Thermal Energy Storage Information Exchange Meeting, hosted by NASA-Lewis Research Center (Cleveland, Ohio) on September 8-9. The meeting was organized into four sessions, and about 32 papers were presented. Hoffman chaired Session III, Residential and Commercial Systems Low-Temperature Sensible and Latent Heat Storage.

The second annual meeting will be held in Gatlinburg, Tennessee, on September 29-30, 1977, with ORNL as host.

i. C. J. Swet. (Program manager, Chemical and Thermal Storage Branch, Division of Energy Storage Systems) visited ORNL on September 21-22. Programmatic elements of the Low-Temperature TES Program were discussed.

5.4 Publications

A draft of the proceedings of the Advanced Thermal Energy Storage Workshop (Baton Rouge, Louisiana, April 23-24, 1976) was received for review. Our comments have been returned to Dr. Ozer Arnas (Louisiana State University), who will assemble the final document. Publication is awaiting receipt of all other reviews.

5.5 Program Plan

Completion of the Program Plan was delayed by the regrouping of TES management responsibilities into larger areas. This necessitated significant reorganization of the initial draft of the Plan; we currently expect completion of the revised version about the end of November. TRW-Washington Operations is now assisting in this effort.

ORNL/TM-5795

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