

DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150692

PROTOTYPE SOLAR HEATING AND COMBINED HEATING AND COOLING SYSTEMS (QUARTERLY REPORT NO. 4)

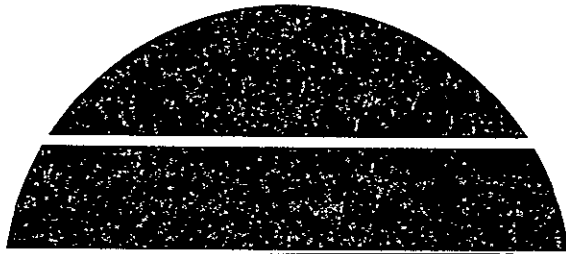
Prepared by

General Electric Company
Space Division
Post Office Box 8661
Philadelphia, Pennsylvania 19101

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For the U. S. Department of Energy



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Solar Energy

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16. ABSTRACT The General Electric Company is developing eight prototype solar heating and combined heating and cooling systems. This effort includes development, manufacture, test, installation, maintenance, problem resolution, and performance evaluation. All cost data have been removed from this report.		
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1 JULY 1977

QUARTERLY REPORT NO. 4
MONTHLY REPORT NO. 12

SOLAR HEATING AND COOLING SYSTEM DESIGN AND DEVELOPMENT

CONTRACT NAS 8-32092

DATA REQUIREMENT NO. 500-10
DATA REQUIREMENT NO. 500-11

PREPARED BY: *K. L. Hanson*
K. HANSON
DEPUTY PROGRAM MANAGER
MSFC-SHAC PROGRAM

APPROVED BY: *J. C. Graf by K. L. Hanson*
J. GRAF
PROGRAM MANAGER
MSFC-SHAC PROGRAM

GENERAL  ELECTRIC

SPACE DIVISION

Valley Forge Space Center

P O Box 8555 • Philadelphia, Penna 19101

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INTRODUCTION

INTRODUCTION

The Quarterly Status Report (Data Requirements Item No. 500-10) provides a summary of the cost, schedule and technical progress of the program. Since it includes and extends the information included in the Monthly Status Reports (Data Requirements Item No. 500-11) it also meets the contract requirement of a monthly status report. It is supplemented by the financial status report (Data Requirements Item No. 500-27) submitted under separate cover.

The report format is:

- Part I - Summary
- Part II - Cost
- Part III - Schedules
- Part IV - Technical Performance

The report is integrated with the program management systems being used on the program, so, where possible, multiple use of program data such as schedules or financial status reports has been accomplished.

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PART I

SUMMARY

PART I

SUMMARY

1.1 COST

This paragraph has been deleted.

1.2 SCHEDULE

The working program schedule is posted on the walls of the Program Control Room and is used to monitor program status at daily "standup" meetings. Reviews with GE management are held in the Control Room to take advantage of the detail schedule data base. A summary schedule is shown in Figure 1-1.

Definition of the Operational Test Sites was a continuing schedule problem. The initial prototype design review was rescheduled and rescoped to adapt to the number and dates of the identified sites. A second mini-design review was held for the second residential heating only site.

EVENT KEYS:

- △ Planned Completion
- ▲ Actual Completion
- ◇ Planned & Actual Slippage

MASTER PROGRAM PLAN

1-2
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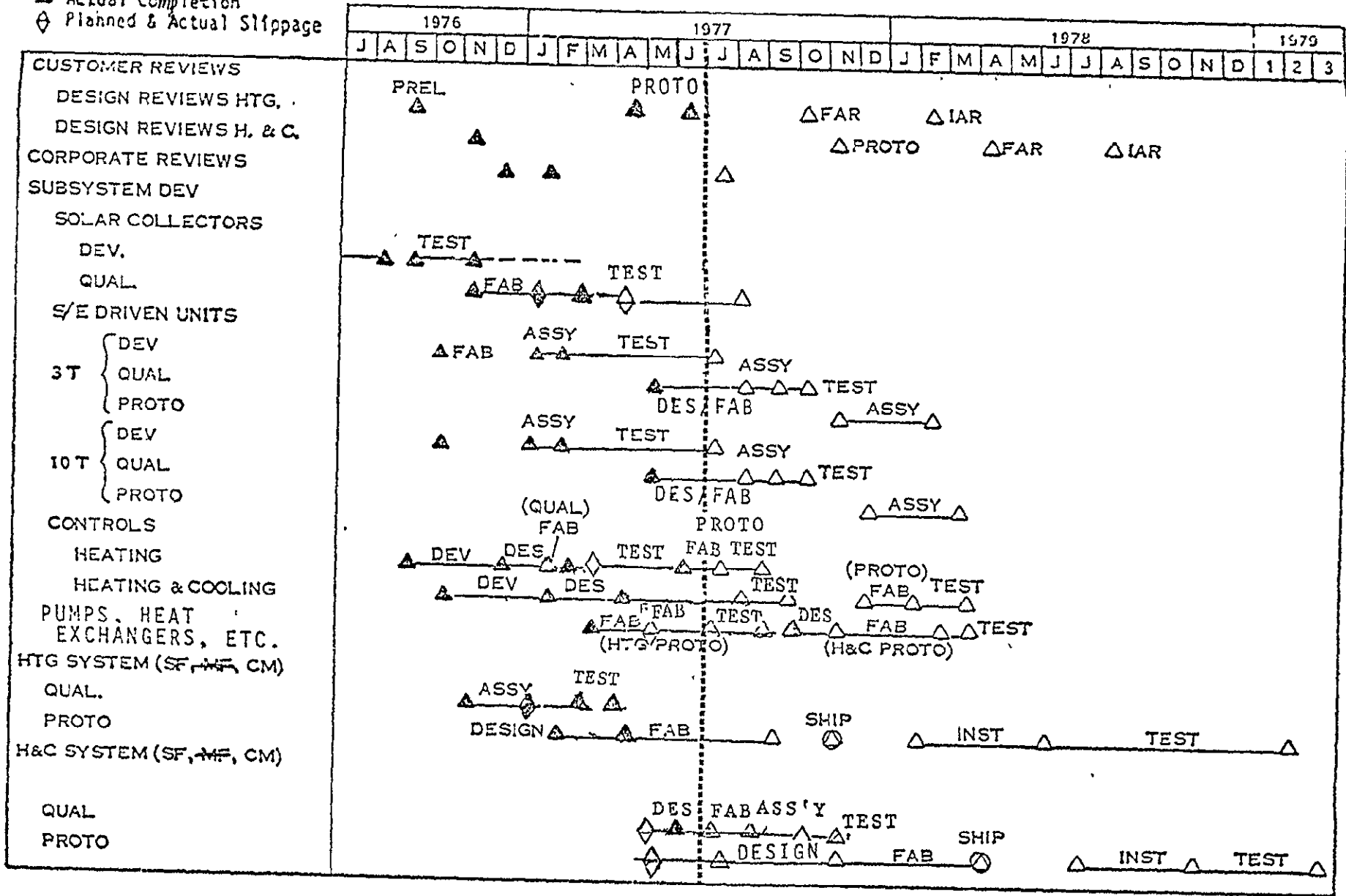


Figure 1-1. Master Program Plan

MASTER PROGRAM PLAN

1-3

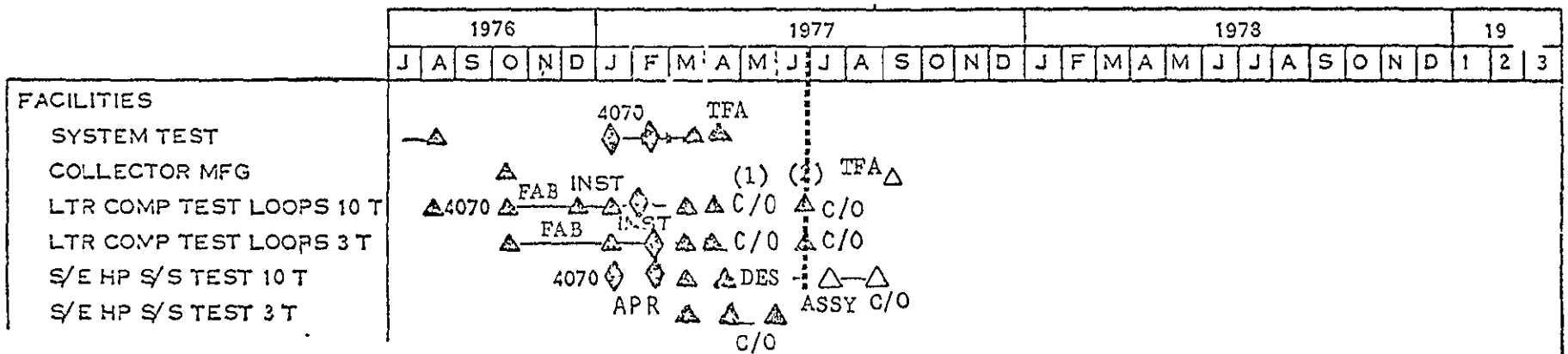


Figure 1-1. Master Program Plan (Cont)

Hardware Testing became an important schedule factor this period. Testing of the qualification collector and low temperature Rankine engine components did not progress at the planned rate of progress this period because of hardware problems. Schedule adjustment in the cooling subsystem will be required. These are reflected in a change proposal being prepared.

1.3 TECHNICAL PERFORMANCE

1.3.1 PROGRAM MANAGEMENT

Program direction control continued per plan. Highlights of the period included two meetings with ERDA and NASA; and heating system prototype design reviews. Direction was received to eliminate the multi-family systems from the development and deliverable hardware tasks.

1.3.2 DEVELOPMENT

System activity this period was primarily in support of operational test site designs. Tradeoff studies were conducted to determine the impact of moving the hydronic coil downstream from the auxiliary heat source (they are very small).

Solar collector activities focused on the resolution of the TC-100 shroud breakage problem. An independent failure analysis team was established and has reported its findings. The principal cause of the problem is considered to be scratches in the inner tubes. Steps are being taken to reduce the residual stresses and to improve the processing of this item. Samples to test the parts made by the new process are being manufactured. Significant progress was made in the design and validation of the design for integration hardware. Primary loop tests were completed.

The relocation of the hydronic coil resulted in minor changes to the control subsystem. Two additional relays are required.

Activity in the auxiliary equipment area focused on modifying the specifications so that the orders could be placed for these equipment items at a reasonable cost. NASA strongly recommends that the horizontal TES tank configuration be tested. A design review of the Energy Management Module was held and the vendor is initiating his program.

In the solar cooling development task, effort was focused on improving expander performance and eliminating vane breakage. Performance studies were completed which show the importance of EER. Goals for Model 2 designs were established and early design activity initiated. All hardware elements are being reviewed with respect to Model 2 design concepts.

Test activities in support of the program continued. By the end of the period facility availability or operation were not program limiting. The second set of Rankine component test loops have been completed but require modification to incorporate key features that have been built into the first set.

1.3.3 DELIVERABLES

Go ahead was received on the heating single family system except for glass shrouds. Consequently hardware orders are being placed with feedback on the specification items that are causing vendor problems being supplied to the design engineers. Detailed hardware schedules are being prepared.

1.3.4 OPERATIONAL TEST SITES

Design activity proceeded on the two residential sites and design reviews were accomplished. The first site, Ft. Meade, was cancelled. Currently, the emphasis is on the Normal, Illinois site. Commercial sites were identified this period and design activities initiated.

Site selection continues to be a problem and is a program pacing item in some areas.

1.4 VARIANCES

Requested variance data is summarized in Table 1-2.

PART II

COST

This section has been deleted

PART III
SCHEDULES

PART III

SCHEDULES

Summary program schedules are shown in Figures 3-1, 3-2, and 3-3. These schedule data are extracted from the detailed program working schedules posted in the Control Room at Valley Forge.

Figure 3-1 is the summary key events schedule. Significant scheduled customer events included a prototype design review for the heating systems with emphasis on the Ft. Meade site which was the site which had been detailed designed. Other size systems were treated in a general fashion. The prototype design review was extended to cover the Normal, Illinois site late in this reporting period. In addition, the quarterly program review for April, May, and June was held late in June.

The key activity in the solar collector area was the shroud design investigations carried out by the program team and the failure analysis team. The failure analysis team released its findings and follow-up activities are underway. New shrouds will be available shortly for evaluation and test. Shrouds for the qualification test series are being fabricated.

Solar cooling development activity continued with emphasis on expander tests. Progress was made in improving the performance of both size units and probable vane breakage factors in the 3-ton size were identified. Assembly of the Cycle 1 3-ton unit is underway and has proceeded to the point of installing the controls elements. Initial testing and checkout will take place with an expansion valve simulating the expander. Recommendations regarding upgrading the solar cooling with respect to commercialization were made to NASA during this period and discussed with ERDA on June 30.

In the controls area the in-house fabricated solar integrator units passed the qualification tests and a vendor (ZIA) was selected to fabricate the production units. Minor changes were made in the control modes to be used for both heating and heating and cooling systems.

The pumps, heat exchangers, etc. for the first residential system are in the ordering process. Specifications have been prepared and vendors are being requested to provide items to these specifications. The conflict between specification requirements and commercial practice are being identified and resolved. The horizontal TES tank for the Normal, Illinois system was ordered. No detail designs for the commercial systems have been completed so none of these items are on order.

Activity in the heating and cooling system area has been very limited. Only one site has been identified to date and the problems with the expander have delayed activity in this area.

The facilities items of most interest, though not a part of the contract, are the collector glass shroud processing equipment. The first machine was received at Valley Forge this period (an evacuate and pinch off machine). The pilot production facility installation is being managed by a separate manufacturing team and progress is monitored by SHAC Program personnel to maintain visibility for program needs. TC-100 shroud production is scheduled to begin this Fall. The other test facility needs of the program are on schedules compatible with program needs.

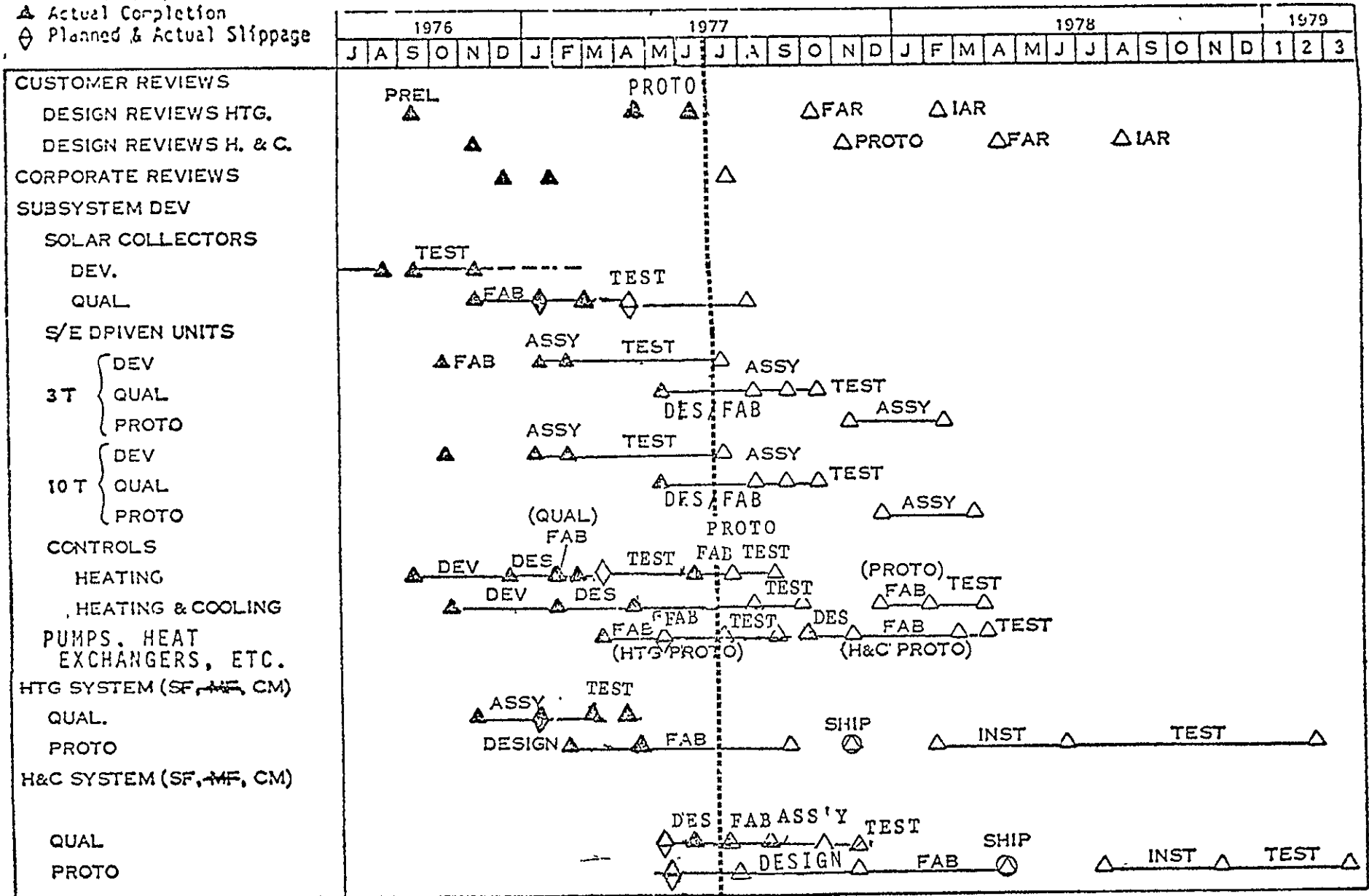
Figure 3-2 is the schedule for the WBS elements. The activity associated with the heating and cooling prototype hardware will be rescheduled as the sites are identified.

Figure 3-3 shows the data deliveries. During this period, all scheduled items were delivered.

EVENT KEYS:

- △ Planned Completion
- ▲ Actual Completion
- ◊ Planned & Actual Slippage

MASTER PROGRAM PLAN

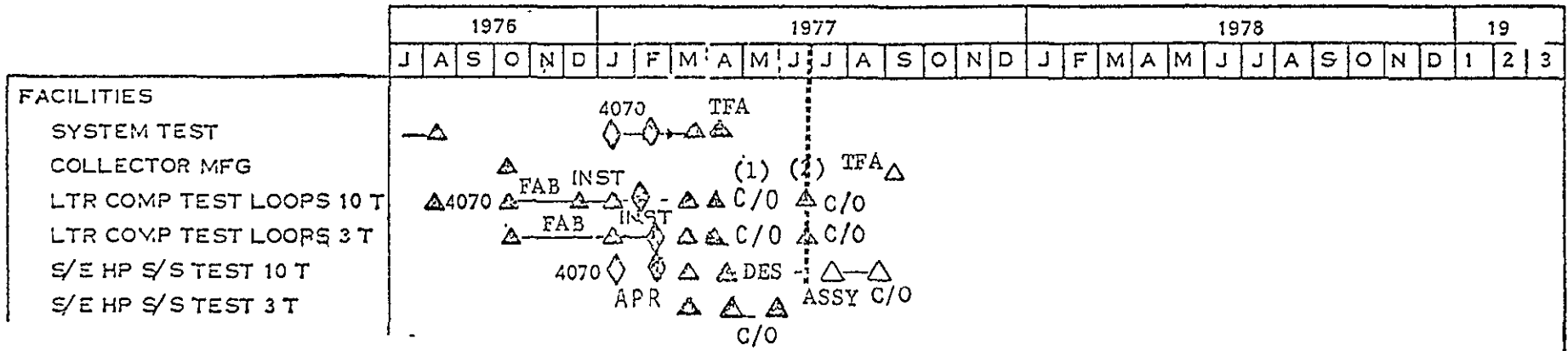


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Figure 3-1. Master Program Plan

MASTER PROGRAM PLAN

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Figure 3-1. Master Program Plan (cont'd.)

PART IV

TECHNICAL PERFORMANCE

SECTION 1

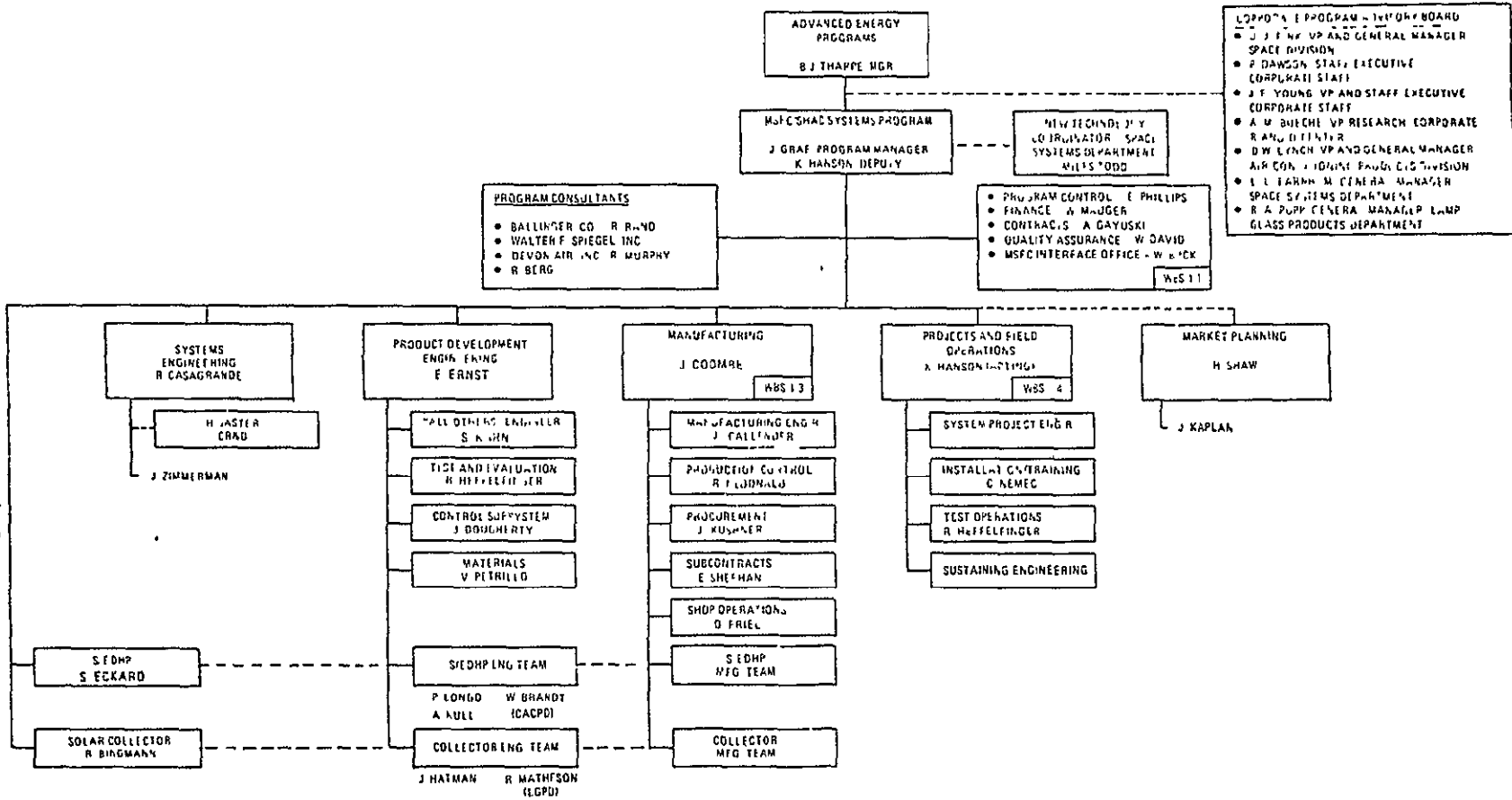
TASK 1.1 - MANAGEMENT

1.1 PROGRAM DIRECTION (WBS 1.1.1)

During this period program operation continued in the manner established during the initial quarters. The program team, shown in Figure 1.1-1, is essentially the one established in the first period with minor modifications. The chart has been updated to reflect the following substitutions: S. Kahn for W. Simpson (previous period); J. Coombe for L. B. Gunnells; S. Eckard for D. E. Bilodeau; and E. Ernst (acting) for D. Matteo.

A discussion was held with NASA and ERDA (and a group of consultants) on April 4. The meeting included a discussion of the elimination of the multi-family operational test sites and other topics initially discussed at the December meeting. The first Prototype Design Review was held on April 20 with emphasis on the Ft. Meade site design but also included general aspects of the heating and hot water systems. A quarterly program review was held on April 21. On May 23 a GE team visited MSFC to discuss program recommendations directed at focusing the cooling program on the development of market required features. A problem working and discussion session on the collector shroud design was held at Valley Forge on May 25 and 26. This meeting included a RIDs working session on the open items from the Prototype Design Review. A Quarterly Program Review and Prototype Design Review (focused on Normal, Ill.) was held on June 28. On June 30 the consulting team reporting to ERDA presented these findings and program direction recommendations were again discussed.

4-2



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Figure 1.1-1. Program Organization

Internal GE reviews were held throughout the period. Included were several reviews with the collector shroud problem analysis team plus solar cooling reviews with management. A Program Review was held with the Division General Manager on May 3 and a Program Review with the Department General Manager on June 10.

On June 17 verbal direction was received that the Ft. Meade site was deleted from the program because of DOD (the landlord) management decisions.

1.2 PROGRAM PLANNING & CONTROL (WBS 1.1.2)

1.2.1 PROGRAM CONTROL

The basic program control tool being used on this program is the control room. It was used during this period to schedule key milestones and program activities and monitor their status. This control room represents the official program schedule against which Ge's technical status and progress is monitored. The scheduled data required for the monthly, quarterly and management reports is extracted from the control room posting. The schedules in the control room include an overall program summary and with detailed task schedules on the side walls. The individual task sections of the control room schedules are monitored and maintained by the responsible task leaders. Daily program status meetings are held to follow hardware items. Problems involving interactions are identified and resolved at these meetings by the assignment of action items which are posted and monitored in the control room.

In the budgets area the program was monitored on the basis of the profile presented in the first quarterly report. Overall budget results are posted

in the control room and are available on a continuing basis for inspection by management. A cost review exercise is currently underway with results to be presented in the next quarterly report.

1.2.2 DATA MANAGEMENT

The scheduled data submittals completed during this period were as follows:

Data Requirements No.

- 3	Quality Assurance Plan (Change 2)
- 8	Prototype Design Review Data Package (2)
-10	Quarterly Report No. 3
-11	Monthly Status Reports (2)
-13	Test Plan for Solar Heating System (Revised)
-14	Test Report - Solar Heating System
-26	Financial Management Report (3)

As of this date RIDs are still outstanding from the PDR's.

1.2.3 CHANGE CONTROL

The status of Change Proposals is as follows:

CP001 - Approved with exception of 001-6

CP002 - Cancelled

CP003 - Ft. Meade Site Design - Submitted 5/12/76

CP004 - Multi-Family Deletion - Response to RCP-301-77-010 - In Process

CP005 - Response to 70-001 - Instrumentation Plan - In Process

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1.3 QUALITY ASSURANCE (WBS 1.1.3)

Change 2 to revision A of the Quality Assurance Plan was released this period. The change stressed that while Inspection Personnel are trained and certified for special processes, manufacturing personnel would be trained but not certified.

Significant Quality Assurance Activities

1. A great deal of Quality Assurance time has been spent in failure analysis of excessive shroud breakage and corrective measures are still being investigated.
2. Receiving inspection planning has been generated for all TC-100 collector purchased parts and effort is now directed to inspection planning for in house fabrications.
3. Qualification status for "off-shelf" hardware has been resolved.

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SECTION 2

TASK 1.2 - SYSTEM DEVELOPMENT

2.1 INTRODUCTION

The major program development activities this period included the continuation of the test program in the solar cooling subsystem development wherein expander problems were investigated and performance improvements incorporated into the test articles. Another major activity area was the investigation of the design of the TC-100 shrouds as a result of the breakage problems that developed. Prototype design reviews were held for two residential heating sites. Results of the development activities are presented in this section organized by WBS elements.

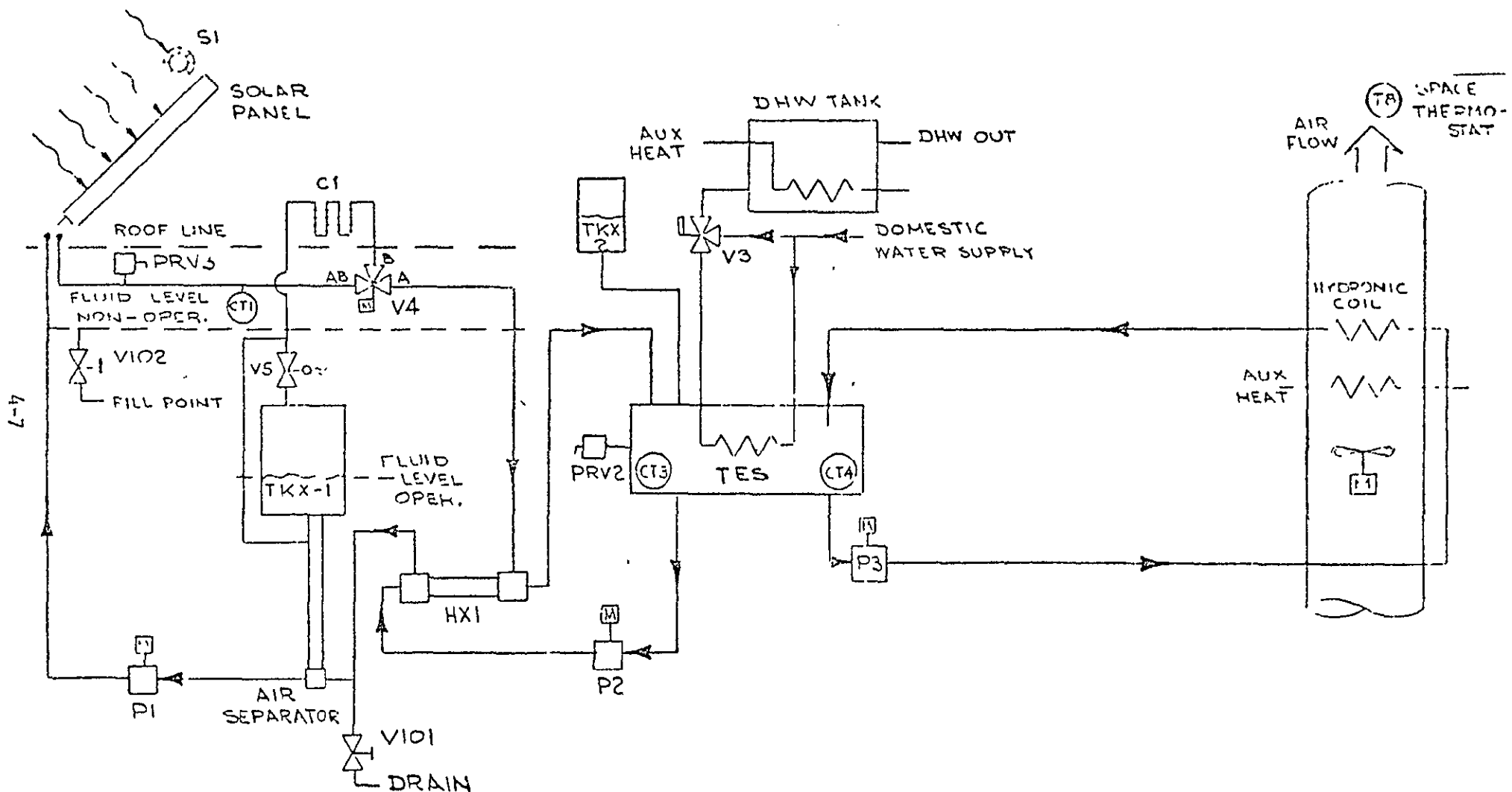
2.2 ANALYSIS AND INTEGRATION (WBS 1.2.1)

2.2.1 BASELINE SYSTEM CONFIGURATIONS

The space heating portion of the single family heating only and heating and cooling baseline systems have been modified to allow the hydronic coil placement downstream of the auxiliary heat source. A study of the effect on system performance is discussed in Section 2.2.2. A revised system schematic diagram for the heating only system is shown in Figure 2.2-1.

The heating season control of the heat pump was modified to eliminate the three stage thermostat previously used. Either the heat pump or solar coil will operate when the first stage calls for heat depending on the temperature of the TES tank. The second stage of the thermostat will activate the electric heaters to satisfy the space energy requirements. A re-evaluation of the required minimum TES temperature for this mode was made and is reported on in Section 2.2.2.

2.2.2 SYSTEM TRADE STUDIES



NOTES:
 1. INTERPRETATION OF DWG TERMS
 AND SYMBOLS PER S30014.

Figure 2.2-1. System Schematic SHAC-Heating Only

2.2.2.1 Hydronic Coil Placement

The placement of the hydronic coil either upstream or downstream of the auxiliary heat source was simulated utilizing the solar simulation code to define the optimum location. Placement upstream of the auxiliary heat source would allow a pre-heating of the return air but the fan motor needs to be specified to withstand the elevated temperatures. Downstream placement of the hydronic coil precludes the pre-heat option. It is not feasible to place the coil between the fan and the heat source at this time because of the cost of modifying existing standard furnaces.

Utilizing the Washington, DC environment and GE TC-100 solar collectors, several yearly solar simulations were performed (Figure 2.2-2) to determine the effect of coil placement and the minimum allowable TES temperature. Variations in the hydronic coil placement do not produce an observable change in the solar contribution over the temperature range examined. A very small difference in the auxiliary energy requirement can be observed but the magnitude of the difference is so small that it should not be considered a design criteria.

Variations in the minimum allowable TES temperature for both systems indicates that 95° minimum allowable TES temperature will utilize the maximum amount of solar energy with minimum auxiliary energy requirements.

2.2.2.2 Heat Pump Control System

The solar/heat pump heating system was examined to define the optimum minimum allowable TES temperature. The system utilizes either solar energy or heat pump energy whenever the first stage of the thermostat calls for heat, and the electric heaters are added when the second stages calls for additional energy.

Yearly solar simulations were made utilizing the Washington, DC environment with

SOLAR ENERGY SUPPLIED
AND
AUXILIARY ENERGY REQUIRED VARIATIONS

ASHRAE 90-75 HOUSE IN WASH, D.C.

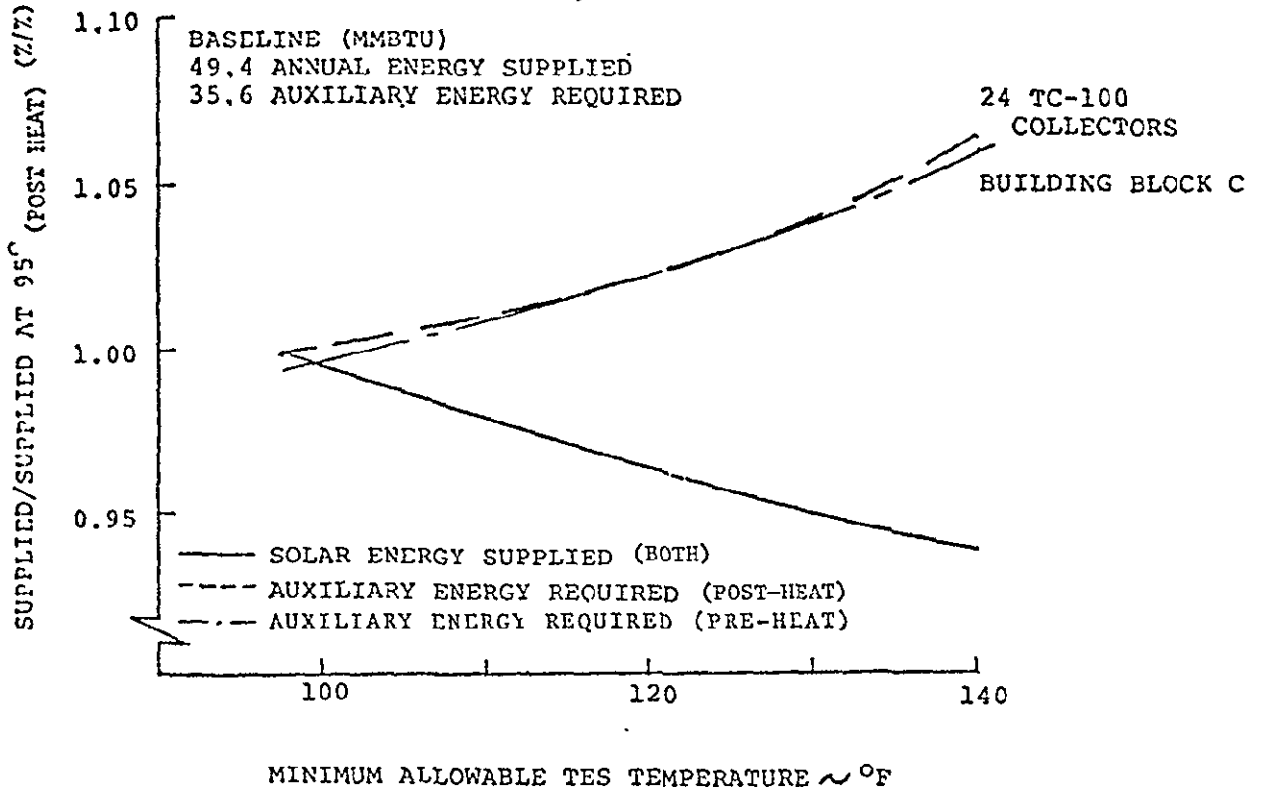


Figure 2.2-2. Solar System Sensitivity to Minimum TES Temperature

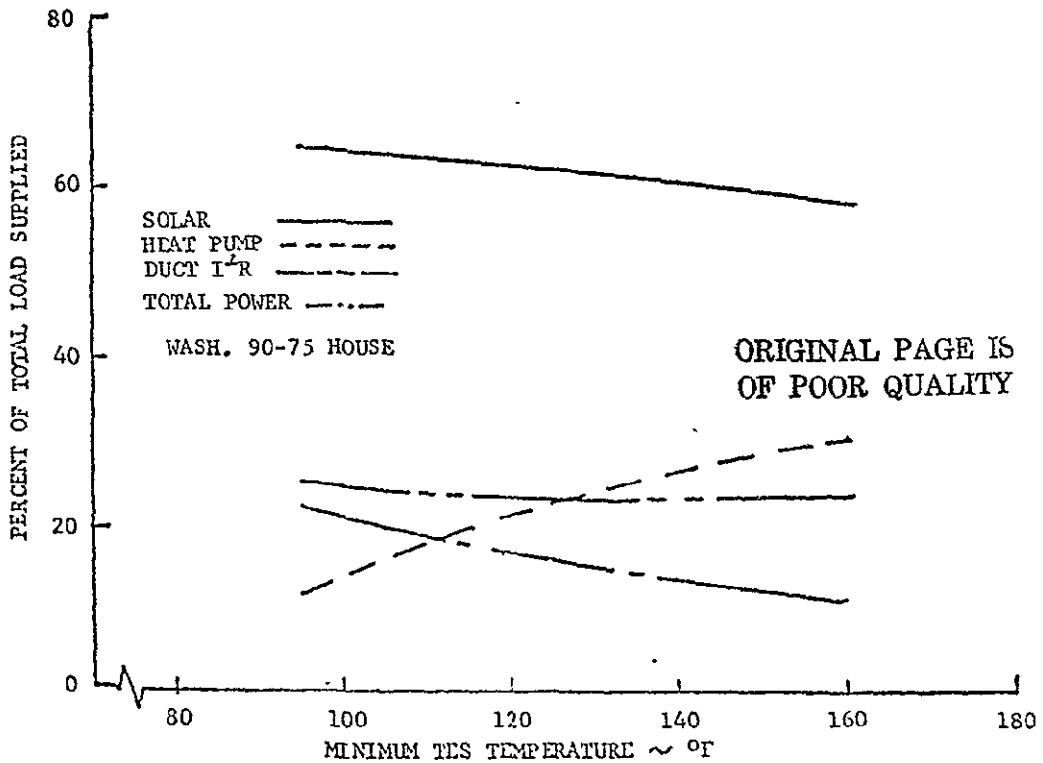


Figure 2.2-3. Solar System Optimization Optimum TES Temperature Heating Season.

several different minimum allowable TES temperatures to define the optimum. As shown in Figure 2.2-3, the amount of solar energy supplied steadily decreases as the minimum allowable TES temperature increases. The total power and electric energy requirements decrease and the amount of heat pump energy supplied increases as the minimum allowable TES temperature increases. The decrease in total power required is related to the increased usage of the heat pump during periods of high efficiency. Also as the minimum allowable TES temperature increases, the heat pump supplies a larger fraction of the load whenever it is operated and the electric heaters will supply a correspondingly smaller amount. The total power requirement becomes a minimum at a minimum allowable TES temperature of 120^oF. This value becomes the optimum TES minimum for the defined operating approach.

2.3 SYSTEM DEVELOPMENT (WBS 1.2.2)

2.3.1 HEATING SYSTEMS (WBS 1.2.2.1)

2.3.1.1 Collector (WBS 1.2.2.1.1)

2.3.1.1.1 Collector Design and Performance Verification

Four performance verification units were built to the design configuration presented in the Quarterly Report No. 3. One unit was shipped to Desert Sunshine Testing for independent performance verification, one unit was assigned to shipping environment tests and two units were assembled aboard a mock roof at the GE/Valley Forge test facility using the integration scheme proposed for residential systems. Immediately after assembly, several shrouds shattered at Valley Forge. Within twenty-four hours, five shrouds had failed. The collectors were immediately removed for inspection in an effort to determine the cause of failure. The rapid occurrence of the failure and the nature of the failure both indicated a drastic change from previous trends.

Initial reaction was that the failures were caused by the one piece fins incorporated into the verification units. However, failures continued to occur illogically, with the many failures occurring when shrouds were in the storage boxes. Table 2.3-1 presents the operational history of the shrouds during this period. Since the solid fin did not appear to be the sole cause of failure, it was decided to establish a failure analysis team consisting of materials engineers and glass experts. Verification testing was temporarily suspended pending the findings of the failure analysis team.

The failure analysis team concluded the following:

1. Nobody really understands glass as a material.
2. We have to learn to live with this lack of understanding and work around it.
3. This means we are involved in an experimental project and must accept the inevitability of problems and change.
4. We are not in a desperate situation, but a typical glass process development mode. Good practice, patience, and perseverance will succeed in the end.

The above general conclusions were cited to establish that glass processing is still an art and that unexpected process related problems are not unusual.

1. Our "E" glass lot was less susceptible to breakage than subsequent "Q" and "S" lots.
2. The only difference found so far between "E" and the other lots is arsenic content.
3. In some applications at Nela Park arsenic glass appears to be sturdier.
4. Because arsenic compounds were found to be carcinogenic it is not possible to return to arsenic glass.
5. There may well be other factors involved that are not now clear.

Table 2.3-1 Verification Shroud Operational History

<u>DATE</u>	<u>EVENT</u>	<u>RESULTS</u>
3/28	Initial Installation	Two Shrouds Shattered in <2 Hrs.
3/28	Broken Tubes Replaced	Third Shroud Shattered on Startup
3/29	Morning Inspection	Two More Shrouds Shattered Overnight
3/29	Collectors Disassembled	
4/11	One Unit Reworked, Reinstalled	One "E" Tube Cracked in Dewar on Original Installation
4/11 → 4/21	Collector Test	Success
4/21	Inspect Fins on Successful Unit	Two Units Shattered
4/20	Functional Fit on DST Unit	Success
4/22	Pack Shrouds for Shipment	Two Shattered in Box
4/22	Units Washed	One Shattered in Box in PM
4/23	Boxes Checked for Breakage	Five Shrouds Found Shattered

4-12

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The following recommendations were made:

1. Use inner tubes with less permanent tensile stress on the inside surface.
2. Use anti-scratch coatings.
3. Improve housekeeping and cleanliness.
4. Redesign fin/tube interface to reduce scratching.
5. Prevent weathering of tubes before heat sealing or wash before sealing.
6. Possibly go to thicker wall.

All of the above recommendations have been accepted in full or in part except for item 6, which after detailed stress analyses, indicated that little is gained by going to a thicker wall. Major emphasis is being placed on the prevention of scratches which contributed in all cases to the failure.

To prevent scratching the following immediate actions are being taken:

1. Each fin will be protected from factory and field debris by a plastic tube covering installed in the factory immediately after the fin is fabricated and left in place until the time of shroud installation.
2. Each shroud will be independently sealed in a dirt proof bag.
3. A lubricant will be installed in each shroud prior to shipment.

To date, two lubricants appear to be attractive. These are a dry carbon film and a silicon compound. Both are presently under development as a simple means of preventing excess scratching. Final screening will be completed by the end of July.

Both the GE and DST performance verification tests have been rescheduled for a late July startup. This date corresponds with the anticipated resolution of the lubrication development program.

2.3.1.1.2 Collector Integration

Design drawings have been issued for the prefabricated manifold, manifold cover and various mounting arrangements. Sample hardware has been built and assembled into a mockup to check functional fits and establish assembly time.

A final protective cover concept has also been selected. Design drawings have been issued. The basic design consists of 1/8" plexiglass window framed in metal. This window is then clipped to the collector. The window is supported at the center by a post to prevent excessive sag. A Lexan[®] window design similar to the plexiglass window design has also been generated in the event that the plexiglass proves to be too brittle to prevent vandal damage.

2.3.1.1.3 Collector Primary Loop

Functional testing of the primary loop is now complete. In all cases, the loop responded as anticipated. Further operation of the test loop is now under investigation as a materials test loop.

2.3.1.2 Energy Storage

Specification 261A2870, TES Tank Assembly was updated to establish final horizontal tank configuration data.

2.3.1.3 Space Heating and Cooling

Specification 261A2861, Hydronic Coils was issued.

2.3.1.4 Auxiliary Energy Systems

Specification 261A2858, Furnace, Forced Air, was completed and submitted for review and comments. The furnace manufacturer stated he meets industry specifications and was not interested in building to a unique specification.

2.3.1.5 Hot Water Subsystem

No significant activity during the reporting period.

2.3.1.6 Energy Transport Subsystem

The Energy Management Module (EMM) Specification, 261A2889 was finalized and issued. Grundfos Pumps Corporation was selected to fabricate the EMM. A design review was held with Grundfos and the design was approved for fabrication.

2.3.1.7 Controls Subsystem (WBS 1.2.2.1.7)

2.3.1.7.1 System Design

The system design has changed in the last quarter with respect to operation during second stage heating on residential (Single Family) units. Second stage heating occurs when the space thermostat senses that room temperature has fallen 2°F below the set point. First stage heating occurs at 1°F below set point. Earlier system design discussions suggested operating both the solar pump, pump P3 (see Figure 2.3.1.7-1) and the auxiliary furnace on second stage if the TES temperature (T3) were above 95°F. This philosophy was based on placement of the hydronic coil upstream from the furnace such that a pre-heat function was served by the low grade (< 120°F) solar heat.

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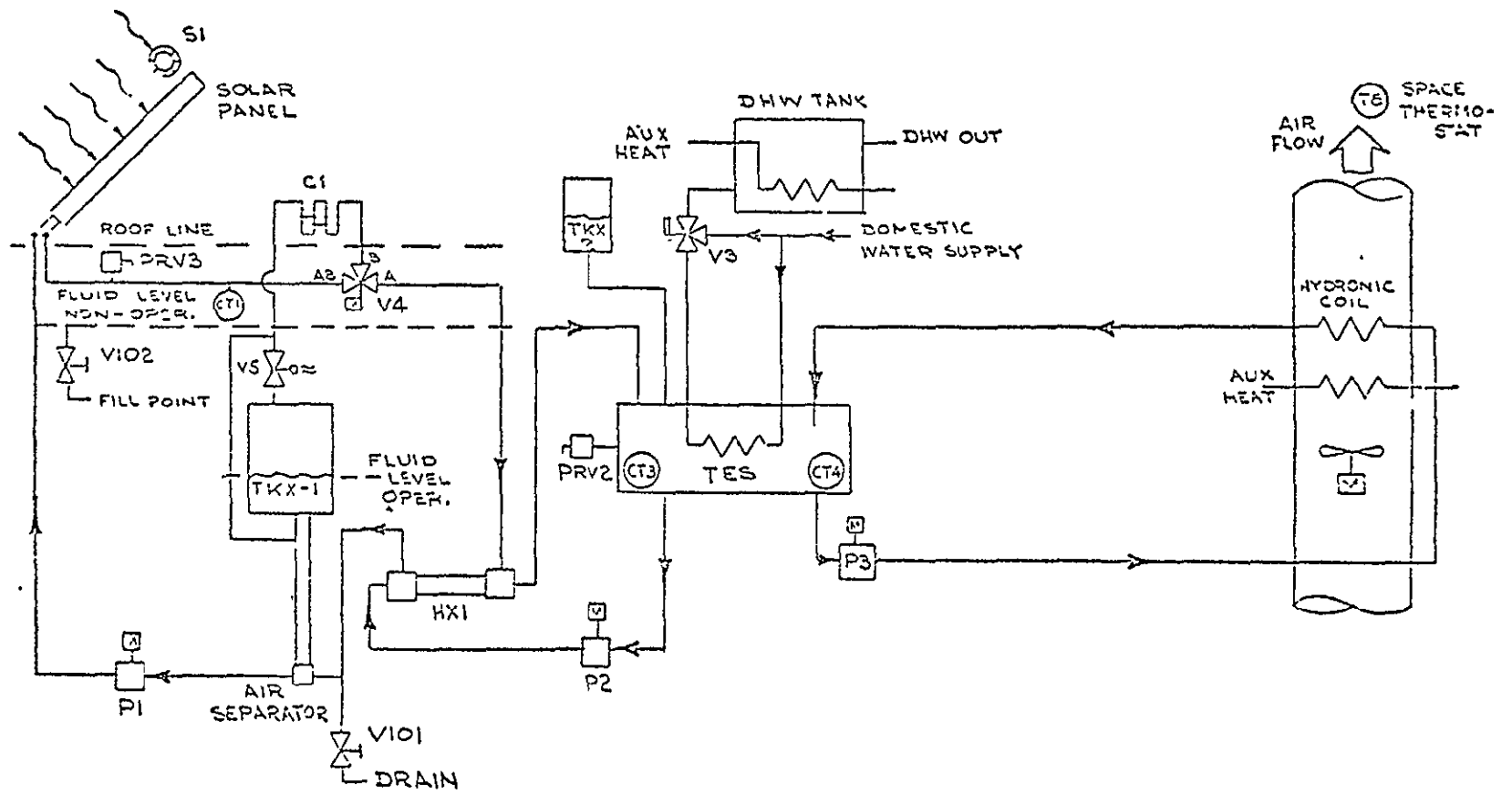


Figure 2.3.1.7.-1. System Schematic - HSF

An evaluation of the hardware available in the HVAC market has shown that the hydronic coil must be placed downstream of the auxiliary furnace. To avoid the removal of heat from the plenum, the solar distribution pump, pump P3, must be de-energized when the furnace is operating.

2.3.1.7.2 Component Development

2.3.1.7.2.1 Sensors - Sensor development has continued in two areas during the reporting period; thermal switches and the solar integrator.

A decision was made to use immersion thermal switches as the over-temperature and distribution-level sensors. Honeywell will be the vendor for the deliverable units, supplying a thermal expansion type standard unit in all cases.

The Solar Integrator, an electronic logic package which controls the collection and energy storage loops based on solar insolation level, has passed qualification testing on two in-house fabricated units. ZIA Associates in Boulder, CO. has been selected as the vendor for this item. Zia has started work on design and fabrication of the deliverable hardware. The Zia units will be qualified before delivery.

2.3.1.7.2.2 System Controls Package - The central control unit for Heating Systems has changed in the past quarter due to the changes in the system design. The unit now requires five (5) relays as compared to the three devices listed in the Quarterly Report No. 3. The Heating Controls Package will be assembled as part of the Energy Management Module. In addition to the relays, the package contains a Class 2 24 Volt transformer and three terminal strips for field wiring.

2.3.1.8 Electrical Subsystem

As previewed in the last quarterly report, the Heating Control/Electrical Subsystem Diagrams, 132D6021 have been completed. The three schematics and six tables

define the various electrical services and disconnect equipment required for the 15 Heating System building blocks.

2.3.1.9 System Integration (WBS 1.2.2.1.10)

During the reporting period, the following significant events took place:

1. The system integration effort on three operational test sites was completed. The Fort Meade single family-heating was designed, but the site was withdrawn from consideration by the Department of the Army. The design for the Normal, Illinois, heating only site was completed and the PDR was held. Architect/Engineering effort on the Normal, Illinois site has been initiated. The Martin Luther King Community Center in Milwaukee, Wisconsin has been selected as the first commercial heating only site. Design activities have been initiated.
2. The heating only system level qualification test report was completed.
3. Component specifications have been issued covering the full range of system building blocks. Vendor negotiations have been on-going throughout this period to insure the hardware specified can be produced at realistic cost in the required quantities. Certain of those components have been procured and integrated into the system level qualification test set-up.
4. The design of the Energy Management Module (EMM), was completed.

This unit will house the following portions of the system:

- collector loop heat exchanger, HX1
- collector loop pump, P1
- collector loop expansion/drain-down tank
- TES loop pump, P2
- Distribution loop pump, P3

- controls package
- interconnecting piping

This unit is intended to facilitate system integration by:

- compact packaging/handling/installation of the above components
- minimizing plumbing connections at site installation
- insuring against improper application/matching of the housed components in the field.

2.3.2 HEATING AND COOLING SYSTEMS (WBS) 1.2.2.2)

2.3.2.1 Collectors

Refer to paragraph 2.3.1.1 Development carried out for heating system applies.

2.3.2.2 Energy Storage Subsystem

Refer to paragraph 2.3.1.2. Development of hot TES applies.

2.3.2.3 Space Heating/Cooling Subsystem

Use of the heat pump results in different equipment for heating and cooling systems. Activity just starting.

2.3.2.4 Auxiliary Energy Subsystem

Equipment will be different for heating and cooling systems. Activity just starting.

2.3.2.5 Hot Water Subsystem

Refer to paragraph 2.3.1.5. Heating systems work is applicable.

2.3.2.6 Energy Transport Subsystem

Refer to paragraph 2.3.1.6. Heating system work is applicable.

2.3.2.7 Controls Subsystem

2.3.2.7.1 System Design

The system design for Heating and Cooling Systems has changed from the control modes presented at the Heating and Cooling PDR. The collection and storage loop controls remain the same as in the heating systems design; however, the distribution of solar energy in both heating and cooling has changed due to philosophy changes and hardware requirements.

2.3.2.7.1.1 Heating. As in Heating Systems (see 2.3.1.7), the hydronic coil, which was originally designed for installation on the upstream side of the furnace, has been constrained to a downstream location due to available hardware configurations. On first stage heating, (see Table 2.3.2.-1) solar heating is utilized by operating pump P3 (Figure 2.3.2-1) and the plenum fan provided the thermal storage temperature is above 120°F. If the storage temperature is low, the heat pump is operated on first stage. Upon a second stage thermostat signal, the heat pump and the auxiliary heat source are operated regardless of the first stage mode of heating. If the stored solar energy is in operation (1st stage), the distribution pump P3 is de-energized to prevent the removal of heat from the air on the downstream side of the auxiliary heat.

2.3.2.7.1.2 Cooling. On a first stage cooling signal, the solar driven compressor is operated if the thermal storage temperature is greater than 205°F otherwise, the electric compressor is used. On a second stage signal the electric compressor is always operated provided that the solar driven compressor, if in operation on first stage of the thermostat, has operated at least 15 minutes. This will extend solar utilization time.

2.3.2.7.2 Components

Table 2.3.2-1. Heating and Cooling System Design

	PREVIOUS OPERATION		NEW DESIGN	
	TES TEMPERATURE		TES TEMPERATURE	
	≥ 105°F	< 95°F	≥ 127°F	< 120°F
1ST STAGE HEATING	SOLAR HEAT	HEAT PUMP	SOLAR HEAT	HEAT PUMP
2ND STAGE HEATING	HEAT PUMP	HEAT PUMP + AUX. HEAT	HEAT PUMP + * AUX. HEAT	HEAT PUMP + AUX. HEAT
2ND STAGE + 15 MINUTES	HEAT PUMP + AUX. HEAT			

* WHEN SOLAR IS AVAILABLE (TES > 127°F) HEAT PUMP AND AUXILIARY HEAT LATCH ON THROUGH FIRST STAGE

2.3.2.7.2.1 Sensors. Sensors developed and specified for the Heating Systems such as the Solar Integrator and the thermal switches are also applicable for the Heating and Cooling Systems. It was stated in the last quarterly report that no new sensor development was planned. This has changed with the initiation of a design which uses an analog temperature sensor and an electronics board to

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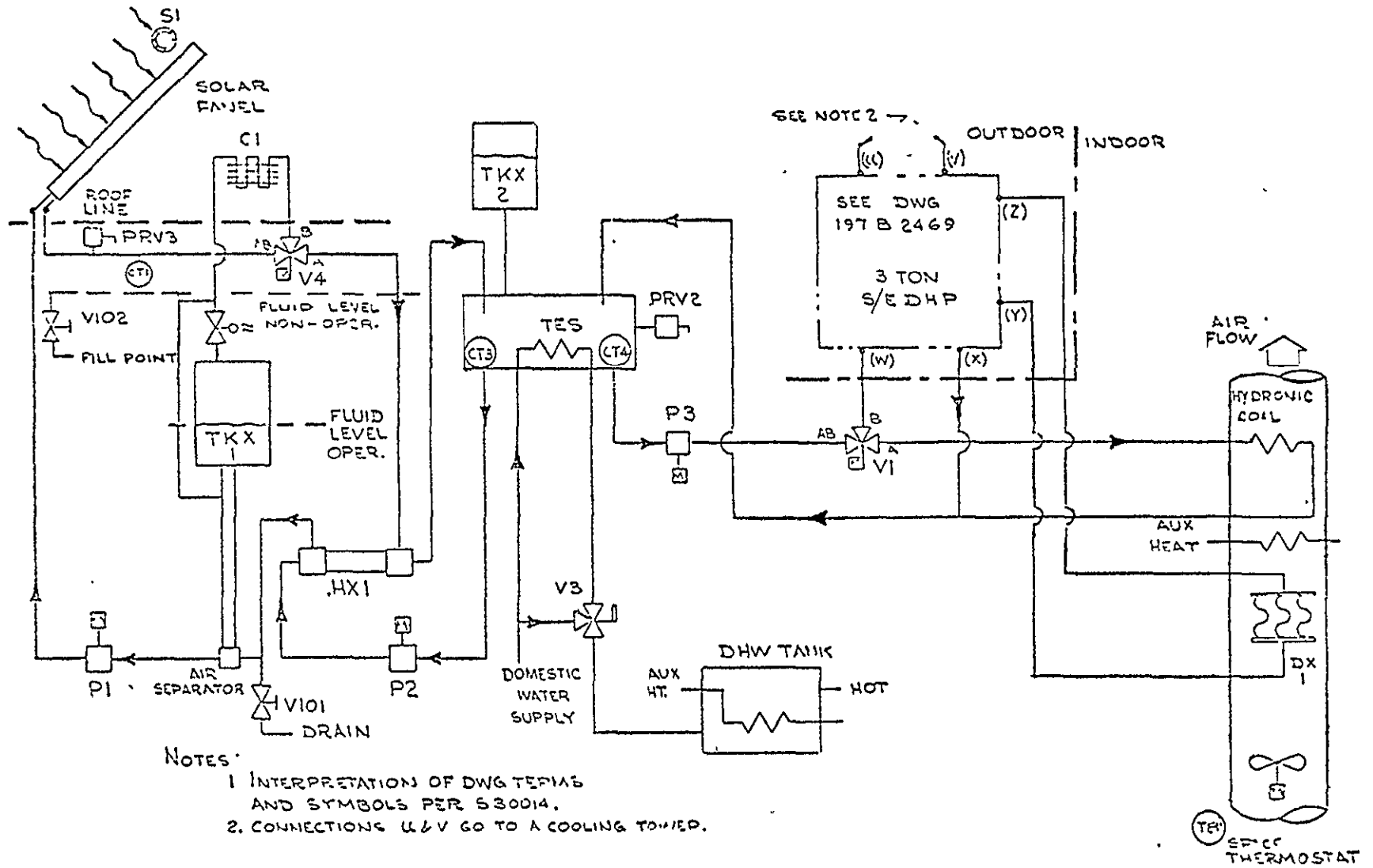


Figure 2.3.2-1. System Schematic - HCSF

provide three temperature switch points from one package. Heating and cooling controls require three separate temperature signals from the thermal storage tank: one for over-temperature, ($> 255^{\circ}\text{F}$), one, for heating ($> 120^{\circ}\text{F}$) and one for cooling, ($> 205^{\circ}\text{F}$). Using the thermal switches applied on the Heating Systems, three separate packages with three immersion wells and three tank penetrations are required. The alternate analog multi-point design is shown in Figure 2.3.2-2. Several electronic configurations are being breadboarded and a specification will be written and released to vendors for quotation.

2.3.2.8 Electrical Subsystem

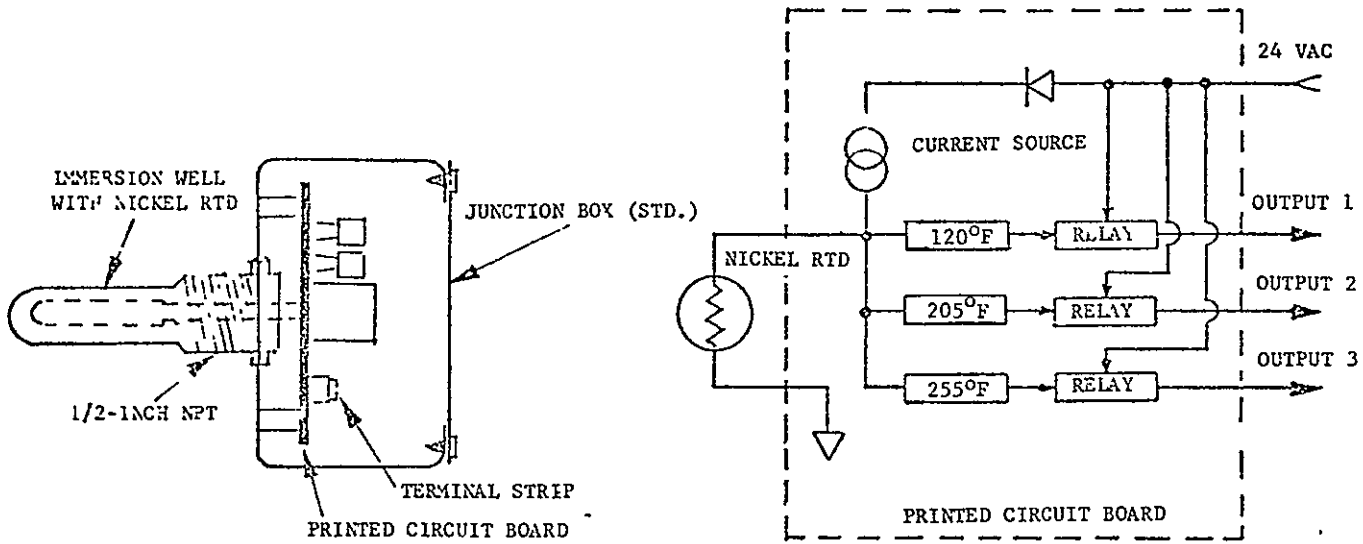
The Heating and Cooling Control/Electrical diagrams, 132D6427 have been initiated in this period and are nearing completion. This drawing number includes three schematics and six tables. This information defines the electrical services and interconnections for the fifteen Heating and Cooling building blocks.

2.3.2.9 System Integration

See paragraph 2.3.1.10. The system integration effort described in that paragraph is also applicable to cooling systems, recognizing that the specific sites mentioned are heating sites.

2.3.2.10 Cooling Subsystems (WBS 1.2.2.2.11)

The following presents the status of the cooling subsystems development effort. These cooling subsystems include a 3-ton solar/electric driven heat pump (S/E DHP), a 10-ton solar/electric driven air conditioner (S/E DAC), and their associated equipment. Schematically, the cooling subsystem approach is shown in Figure 2.3.2-3. Both Model I and Model II development activities continued through this reporting period with emphasis on upgrading Model I component performance and on establishing a test and analytical data base for Model II hardware design efforts.

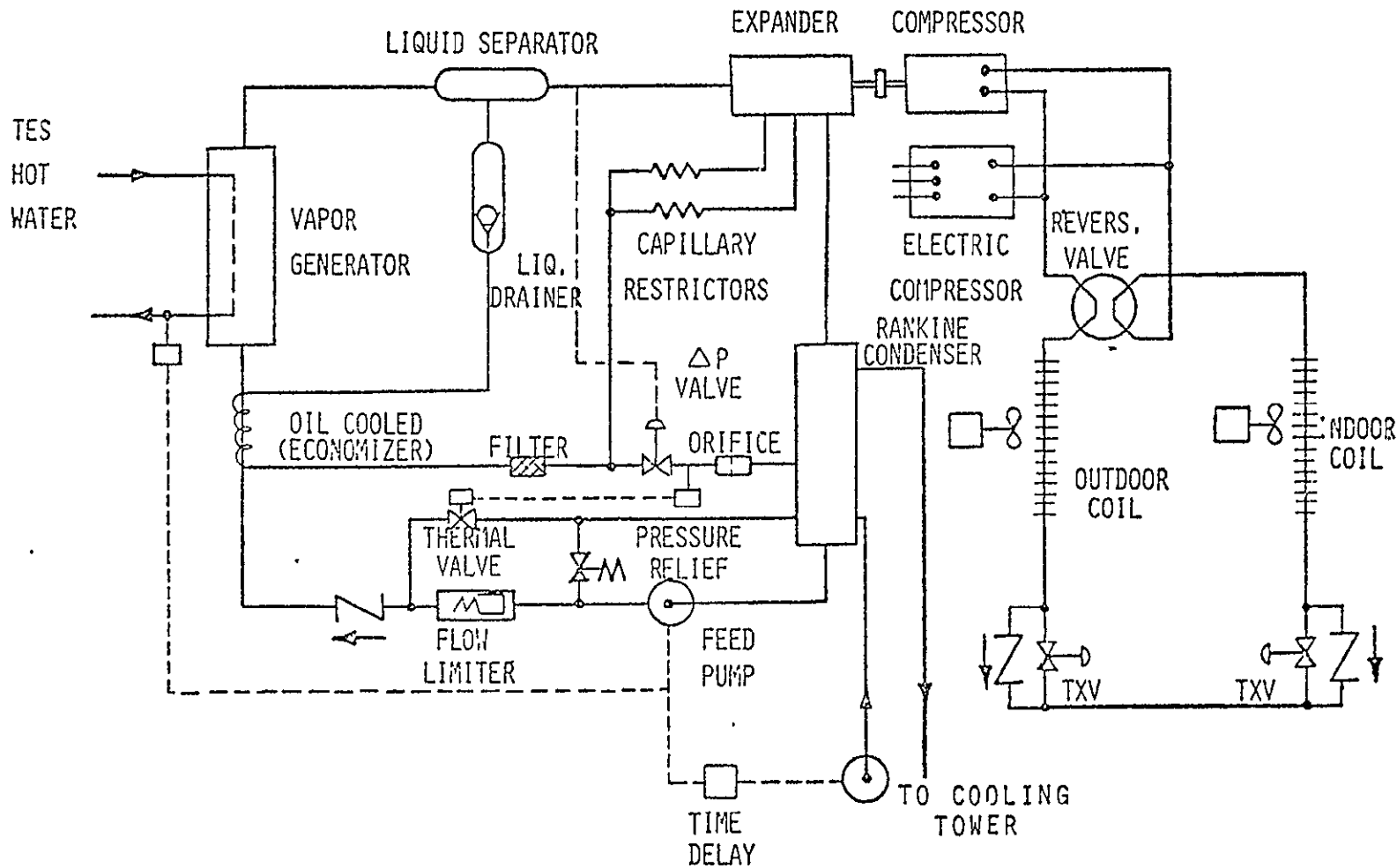


- 1 TANK INSERTION
- 1 INVENTORY ITEM
- LOWER MATERIAL, LABOR COST

Figure 2.3.2-2. Analog Temperature Switch (3 Pts.)

2.3.2.10.1 Subsystem Analyses

Model II performance goals were established and are presented in Figure 2.3.2-4. Analyses were performed, using these performance goals, to confirm, (1) the capacity splits between solar and electric operation, (2) the speed cutoff limits for the expander/compressor and, (3) limits for the vapor generator solar fluid inlet temperature. Figures 2.3.2-5 and 2.3.2-6 depict a summary of the results of these analyses.



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Figure 2.3.2-3. 3-Ton S/EDHP System (Model II)

	"3" TON	"10" TON
CONFIGURATION: CONDENSOR	AIR	WATER
LTR	WATER	WATER
SOLAR COMPRESSOR	5.22 CID, 1730 RPM	16.56 CID, 1730 RPM
CAPACITY AT RATING:	COOLING HTG	COOLING
SOLAR	32 KBTUH	89 KBTUH
ELECTRIC	41 KBTUH 35 KBTUH	120 KBTUH
PERFORMANCE:		
LTR EFF.	11.6%	12.1%
MECH. COP.	5.60	6.26
SOLAR COP.	0.65	0.76
EXPANDER POWER	2.25 HP	5.90 HP

Figure 2.3.2-4. Model II Performance Goals

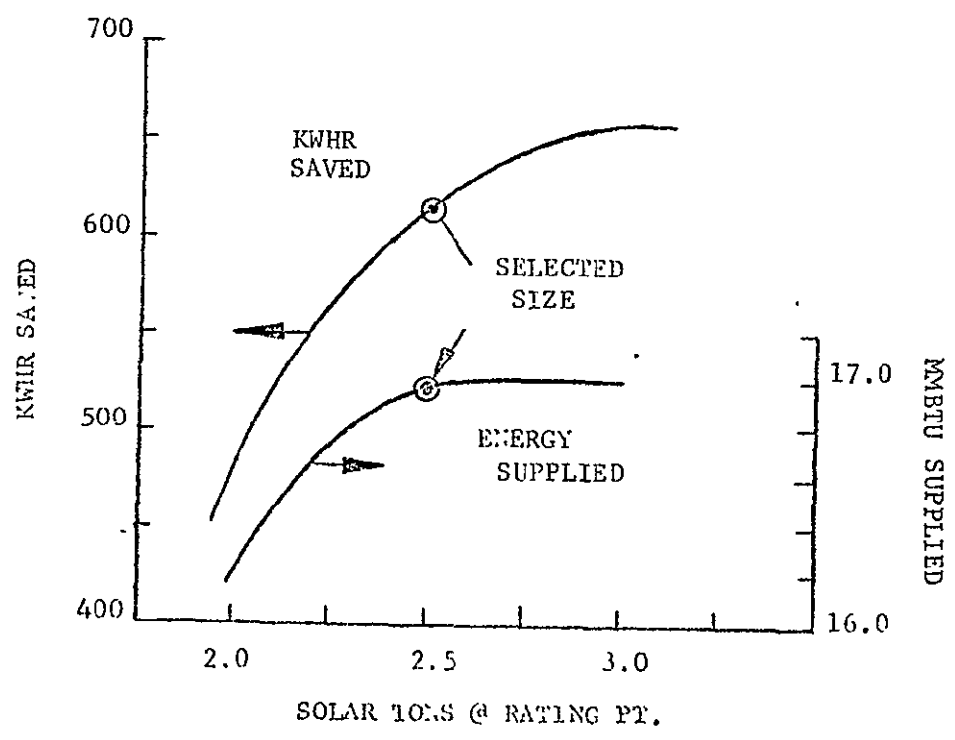


Figure 2.3.2-5. S/EDHP Solar Cooling Sizing

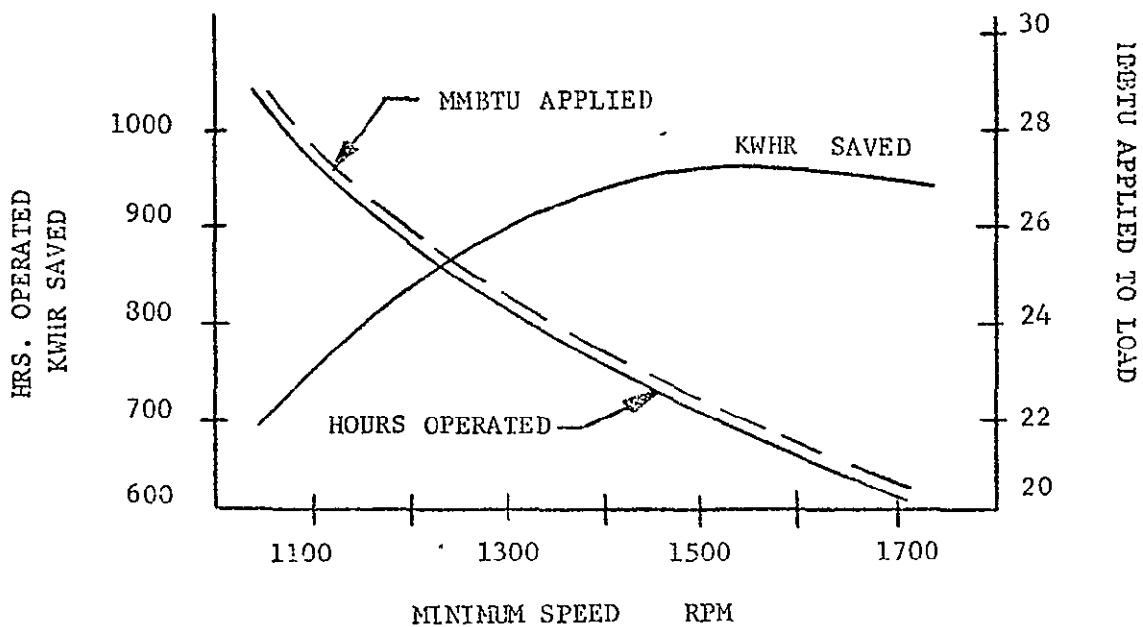


Figure 2.3.2-6 Effect of Low End Speeds On Solar Cooling Operation

2.3.2.10.2 S/EDHP-AC

2.3.2.10.2.1 Expanders. Testing of the Model I 3-ton and 10-ton expanders continued through this reporting period. The 10-ton horizontal expander performance results indicate a measured brake efficiency well below the targeted 80%. Hardware modifications to improve efficiency are continuing with emphasis on reducing internal leakage. A significant improvement has been made in noise reduction by improving vane pressure balancing. To date the Model I 10-ton expander has completed 45 hours of running time at speeds up to 3000 RPM. The Model I 3-ton vertical expander has gone through nine build and test iterations. Vane breakage was a significant problem during early testing, but this problem is now

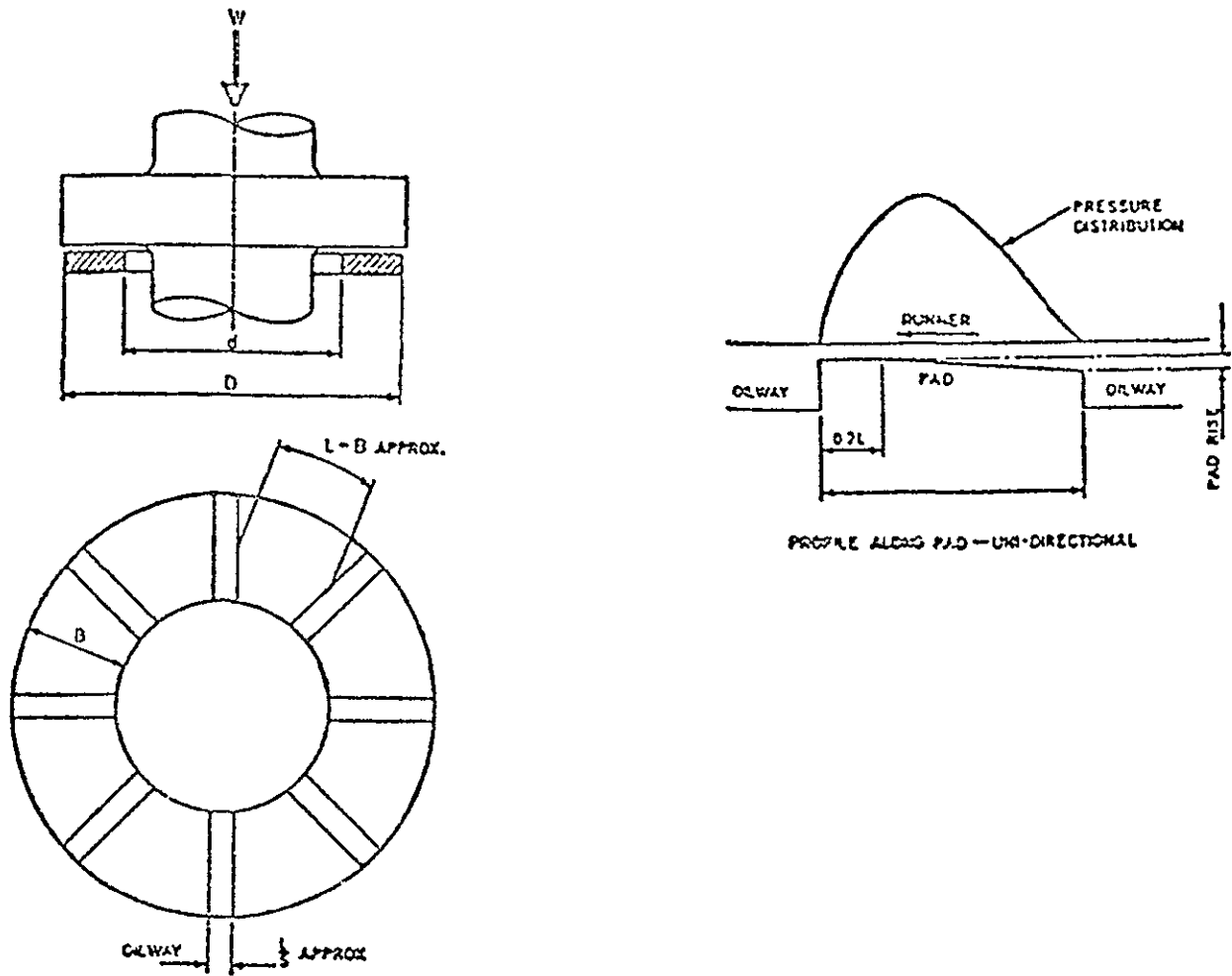


Figure 2.3.2-7 Model II Expander Profiled Pad Thrust Bearings

essentially under control. Noise has been reduced by improved vane pressure balancing. Brake efficiency of the 3-ton expander is presently 66%, and additional hardware changes are in process to further improve efficiency to meet the targeted 75%. Approximately 60 hours of running time has been completed on this unit at speeds up to 2200 RPM. A profiled thrust bearing, as shown in Figure 2.3.2-7, is being evaluated for supporting the vertical rotor of the multi-vane expander. Tests results to date are quite encouraging.

A preliminary Model II expander design is presented in Figure 2.3.2-8. The Model II 3-ton and 10-ton expander designs are nearly identical except for size.

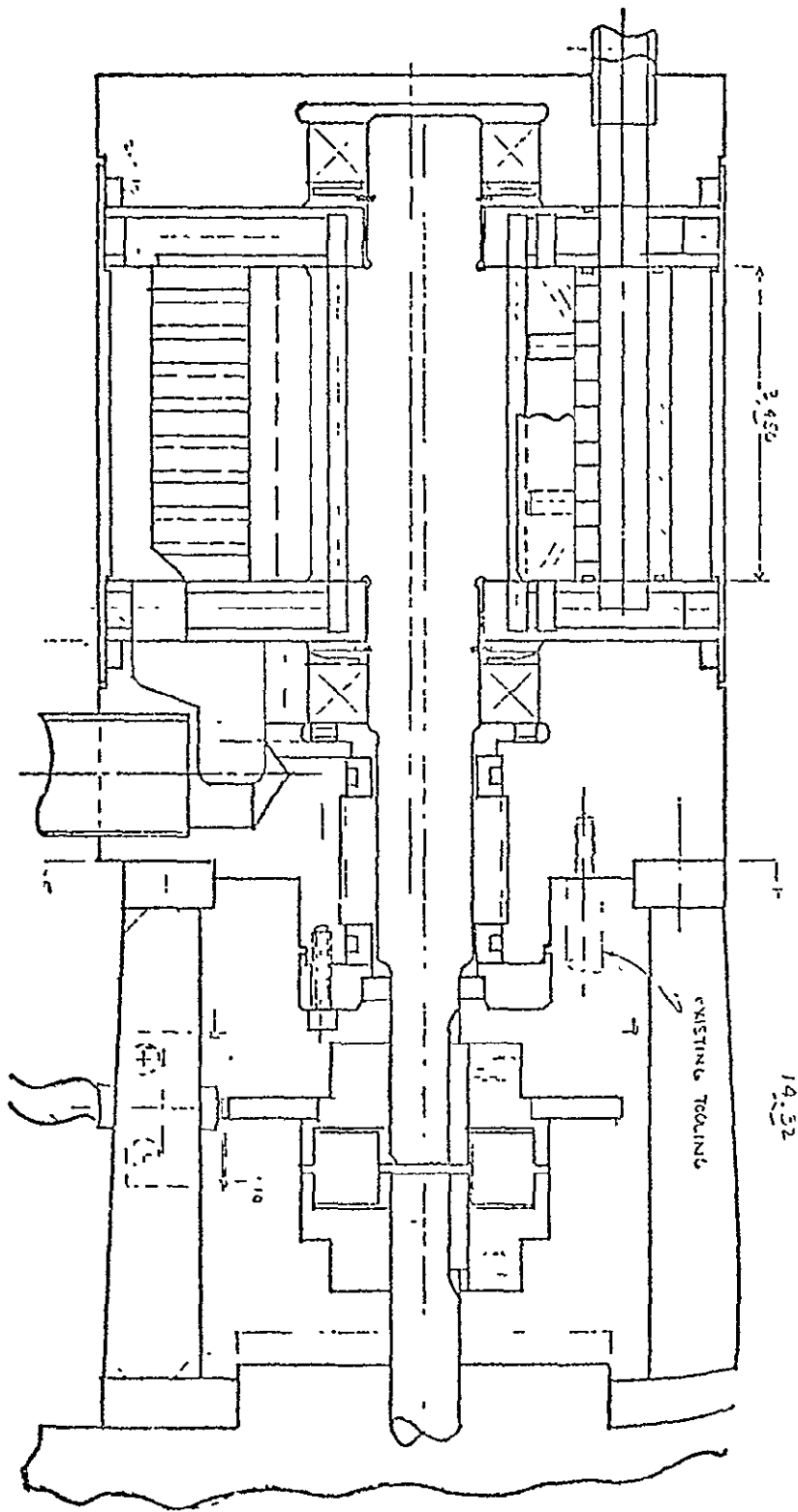


Figure 2.3.2-8. Model 1I Expander Concept

Model II designs include modifications for minimizing internal leakage. Thicker vanes are in the Model II design for better heat dissipation and for higher strengths. The profiled thrust bearing is incorporated in the rotor. General design parameters for the Model II expanders are given in Figure 2.3.2-9. Figures 2.3.2-10 and 2.3.2-11 list Model II expander design objectives and baseline materials.

- 3-TON
 - 2.5 HP AT 1730 RPM (10% SAFETY FACTOR)
 - 130 PSIA, 220°F INLET
 - 21 PSIA OUTLET (95°F COND.)
 - VOL. EXP. RATIO \sim 4.0
 - 96.5% PARTIAL EXP. EFF.
 - 75% PROJECTED BRAKE EFF.
- 10-TON
 - 6.5 HP AT 1730 RPM (10% SAFETY FACTOR)
 - 130 PSIA, 220°F INLET
 - 21 PSIA OUTLET (95°F COND.)
 - VOL. EXP. RATIO \sim 4.1
 - 96.5% PARTIAL EXP. EFF.
 - 80% PROJECTED BRAKE EFF.

Figure 2.3.2-9. Model II Expander Design Parameters

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- MASS PRODUCIBLE
 - AUTOMATIC MACHINING
 - BATCH PROCESSING
 - CASTINGS
 - MIN. HAND LABOR
- MINIMUM PARTS
- LOW COST MATERIALS WHERE POSSIBLE
- INTERNAL MANIFOLDS
- LOW NOISE LEVEL
- SEMI-HERMETICALLY SEALED
- VERTICAL ROTOR
- HIGH PERFORMANCE
- 20,000 + HRS. LIFE

Figure 2.3.2-10. Model II Expander Design Objectives

- ROTOR
 - 410 S.S (R_C 40)
- LINER
 - NITRIDED NITRALLOY - 135 (R_C - 70)
- VANES
 - POCO ACF-100 + T₂C
 - VANASIL - 77 + NITUFF
 - WICKS GRAPHITE 3030 + UCAR - 100
- END PLATES
 - NITRIDED NITRALLOY - 135
 - NI-RESIST + LC-4
- BEARING HOUSING
 - DUCTILE CAST IRON
- OUTER SHROUD
 - 1015 STEEL

Figure 2.3.2-11. Model II Expander Material Choices

2.3.2.10.2.2 Feed Pumps - Model I feed pump endurance testing continued with no problems after 2500 hours of logged running time. The Model II feed pump and the combined feed pump/motor design concepts are shown in Figures 2.3.2-12 and 2.3.2-13 respectively. The 3-ton and 10-ton design approach is identical - the only significant difference is the higher flow capacity for the 10-ton pump. The Model II design permits the pump to be operated in a vertical or a horizontal orientation. Oil flooded sleeve bearings, and an overhung motor configuration will allow eventual integration of the pump/motor into a single hermetic can. Figure 2.3.2-14 presents Model II feed pump design parameters. Figure 2.3.2-15 describes Model II feed pump design objectives and material choices.

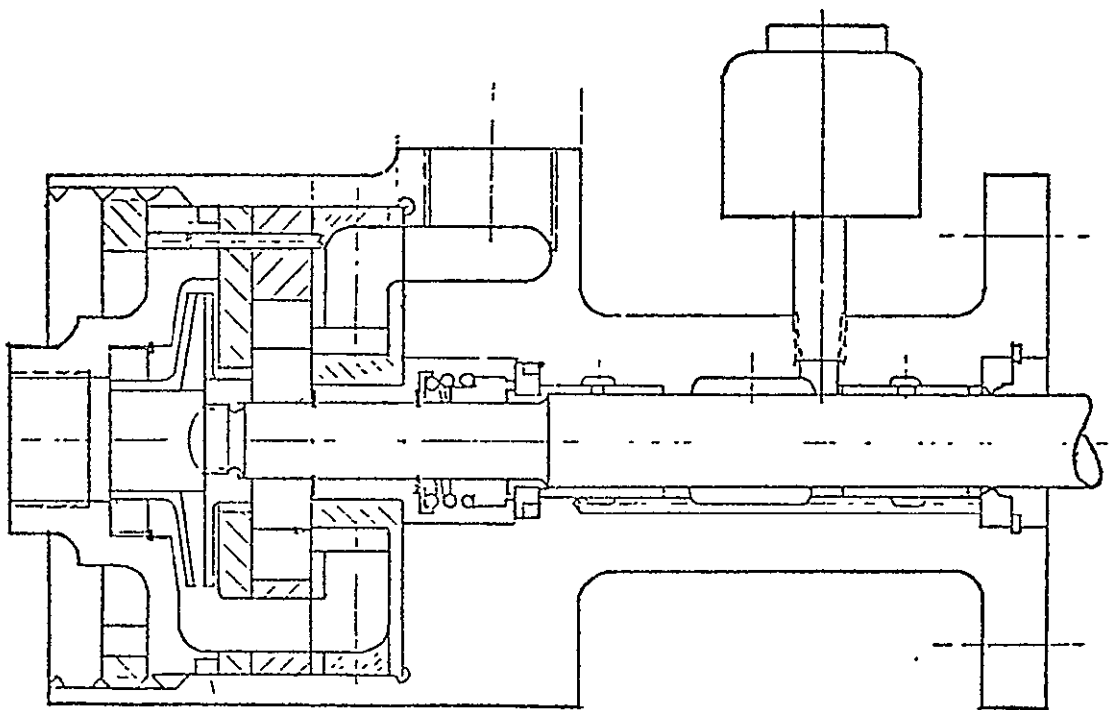


Figure 2.3.2-12. Model II Feed Pump Concept

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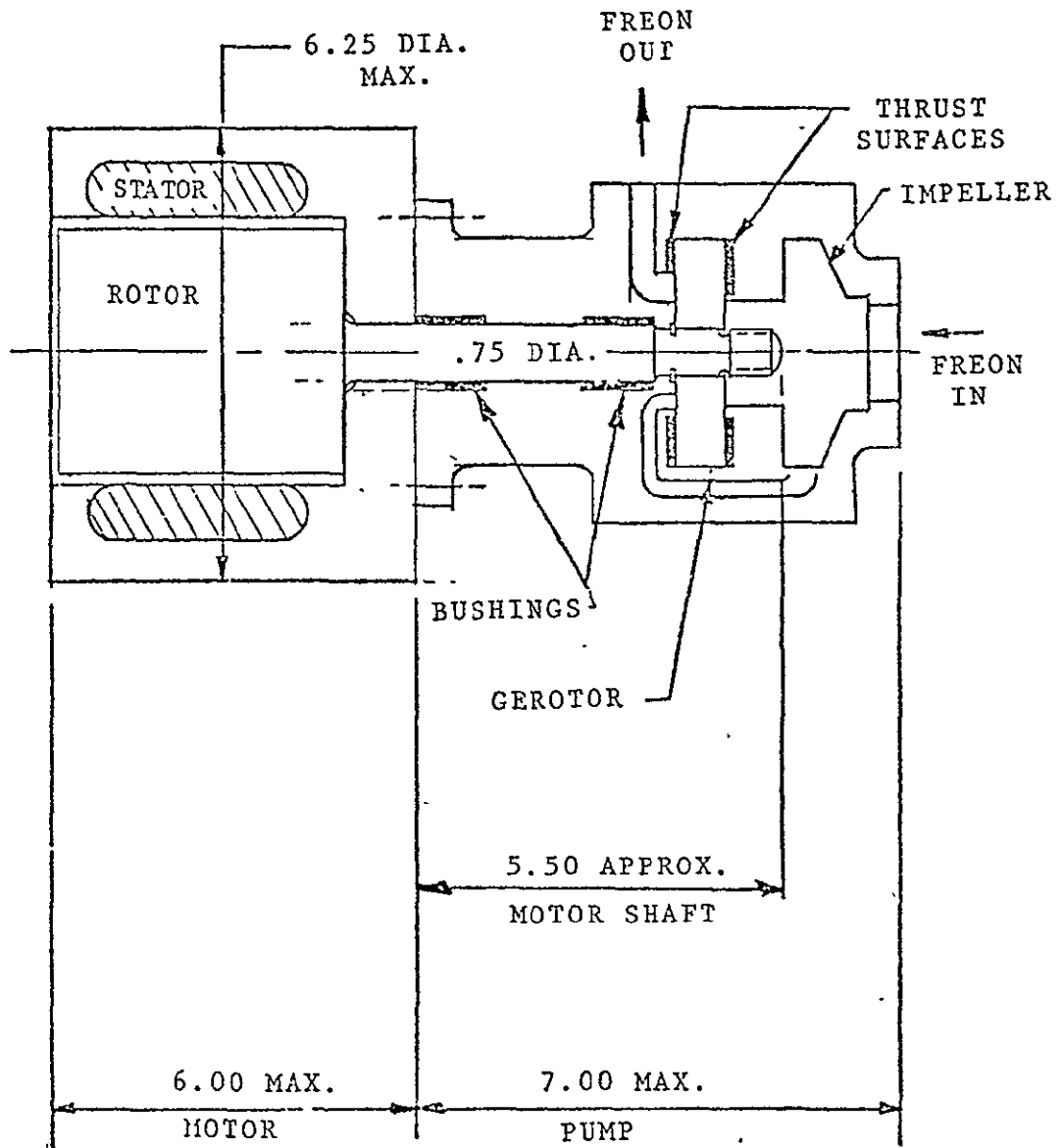


Figure 2.3.2-13. Model II Feed Pump/Motor Concept

- PERFORMANCE
 - HIGH VOL. EFF. AT \sim ZERO NPSH
 - 150 PSI PRESSURE RISE
 - 3450 RPM

	<u>3-TON</u>	<u>10-TON</u>
VOL. EFF.	60%	70%
MECH. EFF.	90%	90%
MOTOR EFF.	60%	80%
DESIGN FLOW	1.13 GPM	2.53 GPM
EXCESS FLOW	25%	20%

Figure 2.3.2-14. Model II Feed Pump Design Parameters

- DESIGN OBJECTIVE
 - MASS PRODUCIBLE (LOW COST CASTINGS)
 - VERTICAL OR HORIZONTAL MOUNTING
 - MINIMUM PARTS
 - DESIGN FOR FUTURE CANNING
 - 20,000 + HRS. LIFE
 - LOW NOISE
 - HIGH PERFORMANCE
- MATERIALS
 - HOUSING
 - DUCTILE CAST IRON
 - GEROTOR
 - P/M CAST IRON (PHOSPHATE COATING)
 - END PLATES
 - NITRIDED NITRALLOY - 135
 - NI-RESIST + LC-4
 - CENTRIFUGAL
 - CAST 17-4 PH
 - SHAFT
 - C1030 ($R_c \sim 30$)

Figure 2.3.2-15. Model II Feed Pump Design Objectives and Material Choices

2.3.2.10.2.3 Heat Exchangers

2.3.2.10.2.3.1 Vapor Generators - Fabrication of two Model I 3-ton vapor generator assemblies was completed, and these units were leak tested under pressurized thermal cycling conditions. One vapor generator has been installed in the Model I S/EDHP test prototype where its performance and interaction with other Rankine engine components will be assessed under various transient and steady state operating conditions. Model I vapor generator hardware was designed as a test component with emphasis on diagnostic instrumentation to verify performance of a tube and shell approach. Model II vapor generator design effort has been initiated, and an active technical interchange is being conducted with several heat exchanger manufacturers. Our unique performance requirements are being integrated into a compact, light weight, low cost, highly efficient heat exchanger design. Figure 2.3.2-16 depicts the relationship that has been established with these manufacturers. Preliminary Model II vapor generator design requirements are presented in Figure 2.3.2-17. These requirements were forwarded to a number of qualified heat exchanger manufacturers for review. After comparing the level of interest and capability of these manufacturers, three were selected for more detail review. Figure 2.3.2-18 presents the manufacturers involved and the key design features in their proposed vapor generator. All are of the tube and shell approach.

2.3.2.10.2.3.2 Condensers - Model I condensers have been installed in the expander test loops and are performing satisfactorily. One 3-ton condenser has been installed in the Model I S/EDHP test prototype where its performance and interaction with other Rankine engine components will be assessed. Model I condensers were purchased "catalog" tube and shell heat exchangers modified by General Electric to provide for additional performance instrumentation. Model II condenser designs are evolving in the same manner as the Model II vapor

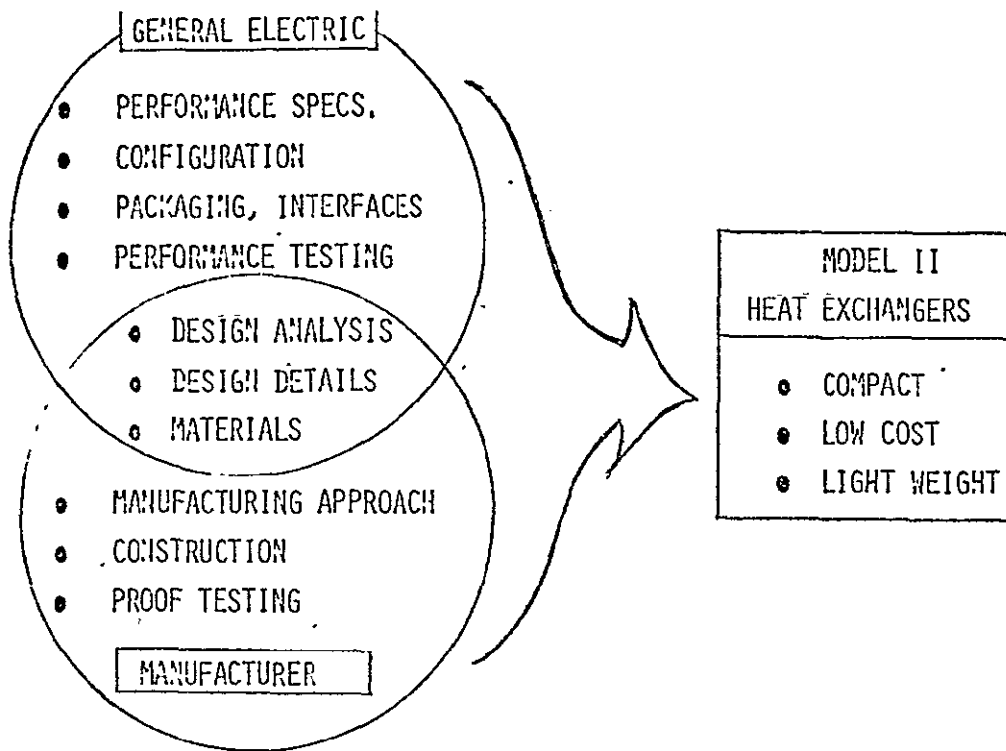


Figure 2.3.2-16. Model II Heat Exchanger Approach

ENERGY, BTUH	3 TON	10 TON
	44,000	115,000
<u>SHELL SIDE</u>		
FLUID	H ₂ O	H ₂ O
MATERIAL	LOW CARBON OR SS	L. C. OR SS
FLOW RATE, GPM	11	30
$\Delta T \sim$ °F	8	8
INLET TEMP. RANGE, °F	200-245	200 - 245
MAX. INLET TEMP., °F	245	245
MAX. SHELL PRESS., PSIA	75	75
<u>PIPE SIDE</u>		
FLUID	R11, 2% OIL	R11, 2% OIL
MATERIAL	L.C. OR S.S.	L.C. OR S.S.
FLOW RATE, LB/HR	550	1500
INLET TEMP., °F	113	113
INLET PRESS., PSIA	130	130
END PIPE TEMP., AVE., °F	228	228
DESIGN VELOCITY, FT/SEC.	15	15
MAX. PIPE PRESS., PSIA	150	150

Figure 2.3.2-17. Model II Vapor Generator Requirements Preliminary

VENDOR	KEY FEATURES
AMETEK, INC. GRAND PRAIRIE, TEXAS	<ul style="list-style-type: none"> • THIN WALL SPIRAL TUBES • THIN WALL SHEET METAL SHELL • EXTRUDED CONNECTIONS • VACUUM BRAZED TUBE BUNDLE • TWO PASS, CROSS-FLOW DESIGN
DUNHAM-BUSH HARTFORD, CONN.	<ul style="list-style-type: none"> • THIN WALL STRAIGHT TUBES • THIN WALL SHEET METAL SHELL • FLOATING HEAD • TUBES BRAZED IN TUBE SHEETS
AMERICAN STANDARD BUFFALO, NY	<ul style="list-style-type: none"> • THIN WALL U-TUBES • TUBES ROLLED IN TUBE SHEETS • USE OF AMERICAN STANDARD STOCK COMPONENTS • VAPOR GENERATOR AND CONDENSER USE COMMON PARTS

Figure 2.3.2-18. Model II Vapor Generator Vendor Approach generators. Figure 2.3.2-19 presents preliminary Model II condenser design requirements. Figure 2.3.2-20 shows the heat exchanger manufacturers involved, and this Figure also shows the key design features being considered.

	3-TON	10-TON
ENERGY, BTUH	38,000	101,000
<u>SHELL SIDE</u>		
FLUID	R11, 2% OIL	R11, 2% OIL
MATERIAL	COPPER	COPPER
FLOW RATE, LB/HR	550	1500
COND. TEMP., °F	95	95
COND. PRESS., PSIA	21.5	21.5
MAX. SHELL SIDE PRESS., PSIA	40	40
<u>TUBE SIDE</u>		
FLUID	H ₂ O	H ₂ O
MATERIAL	COPPER	COPPER
FLOW RATE, GPM	12.5	34
TEMP., °F	6	6
COND. TEMP., °F	83	83
MAX. TUBE SIDE PRESS., PSIA	20	20

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Figure 2.3.2-19. Model II - Condenser Requirements Preliminary

VENDOR	KEY FACTORS
AMETEK, INC. GRAND PRAIRIE, TEXAS	<ul style="list-style-type: none"> • THIN WALL SPIRAL TUBES • THIN WALL SHEET METAL SHELL WITH EXTRUDED CONNECTIONS • INTEGRAL LIQUID SUMP
DUNHAM-BUSH HARTFORD, CONN.	<ul style="list-style-type: none"> • THIN WALL STRAIGHT TUBES; THIN WALL SHELL • INTEGRAL LIQUID SUMP
AMERICAN STANDARD BUFFALO, NY	<ul style="list-style-type: none"> • THIN WALL U-TUBES AND SHELL • CONDENSER SHELL AND TUBE BUNDLE SAME AS VAPOR GENERATOR. • USE OF AMERICAN STANDARD STOCK PARTS

Figure 2.3.2-20. Model II Condenser Vendor Approach

2.3.2.10.2.3.3 Economizers - Figure 2.3.2-21 outlines the approach being taken for the Model II economizers. The economizers are being designed to be an integral part of the plumbing from the pump exit to the vapor generator inlet. The design consists of two tube reducing tees, a tube within a tube and a wire wrapped solid rod in the interior. The outer "shell" of this heat exchanger is the same tube that would run from the pump to the vapor generator inlet. For Model II cycle conditions the amount of energy to be transferred is small; however, due to the simplicity of the design, a lower \$/BTUH transferred can be achieved through the use of the economizer than by adding additional heat transfer area to the vapor generator.

① ENERGY REQUIREMENTS

- 3-TON : 1300 BTU/HR.
- 10-TON : 3650 BTU/HR

① DESIGN APPROACH

- INCORPORATE ECONOMIZER INTO RUN FROM PUMP TO V.G. INLET
- USE OFF-THE-SHELF TUBE FITTINGS FOR HEADERS

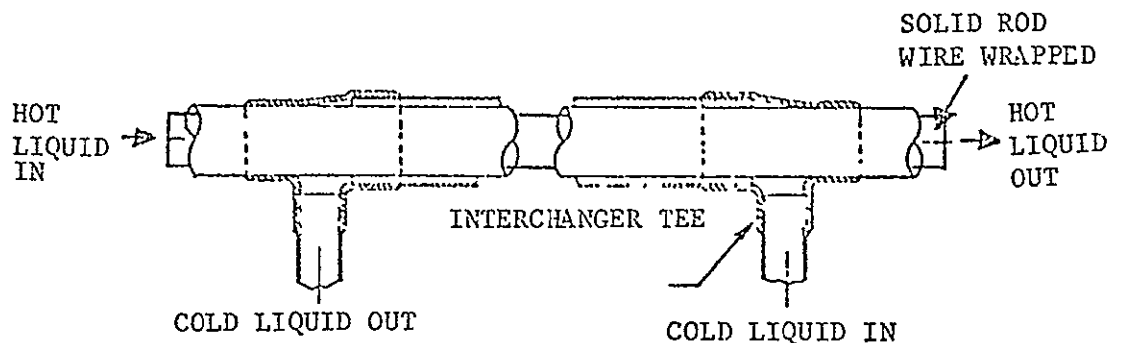


Figure 2.3.2-21. Model II - Economizer

2.3.2.10.2.3.4 Solar Driven Compressors - Model I test activities continued through this reporting period. An accelerated stress life test was successfully completed. This consisted of two cycles of four one week tests where the solar driven compressor was subjected to abnormal transient and steady state operating conditions that introduced high pressure ratios, high pressure stresses, flood restarts, and rapid cycling. The tests were developed from design and field experience as an accelerated means to assess compressor design life. Oil level equalization tests were also successfully conducted on the solar driven/electric

hermetic integrated compressor design. The test conditions were the same as those imposed in the accelerated stress life test described earlier. Under all test conditions and throughout the design operating speed range, an oil level was sustained in both compressors sufficient to provide proper lubrication to the bearing and seal systems. Simulation of expander start-up testing is continuing. These tests involve simulating the time function for the Rankine engine expander to bring the solar driven compressor up to minimum operating speed. The effects of this time on compressor bearing and seal lubrication at low speed conditions is being evaluated. To date a speed ramp of 45 seconds duration has been imposed with no adverse effects. Testing will continue with extended time periods until a compressor lubrication problem is observed. Another series of tests performed on the solar driven compressor involved monitoring capacity vs. shaft watts over the design operating speed range to assess impact on EER. Figure 2.3.2-22 shows the relative insensitivity of the EER throughout the operating speed range.

2.3.2.10.2.5 Heat Pump/Air Conditioner - Two 3-ton heat pumps (split systems) were shipped to GE Valley Forge from GE Tyler. One unit is being used to check out and calibrate the new psychrometric environmental chamber at Valley Forge. This heat pump will later be assembled into the Model I S/E DHP test prototype. The second heat pump will serve as a back-up.

2.3.2.10.2.6 Controls - Model I controls (breadboard design) and fabrication has been completed. The breadboards will be tested in the Model I S/E DHP test prototype to evaluate the digital sequence control and the freon flow control logic. Optimization of the various sequences, event timing and systems operating limits is to be experimentally verified. The digital sequence control portion of the breadboard is a time base of up to a 30 minute delay period. Seven separate delay functions are implemented by tapping stages of a

CM 60 AX
6.21 IN³/Rev.

120°/45°/70°/15°
Capacity - Power - EER
vs.
RPM

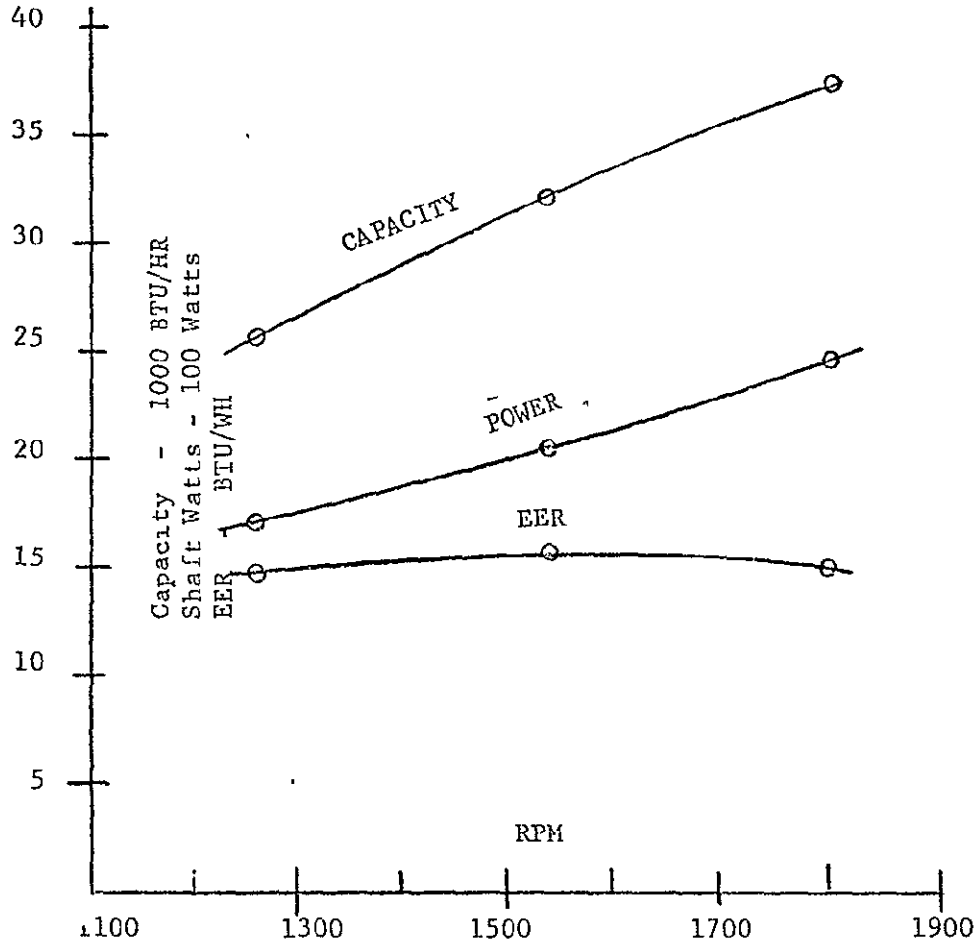


Figure 2.3.2-22. Model I S/E DHP Compressor

14 bit digital counter. One control approach will provide a 15 minute delay for electric compressor start to allow solar cooling operation in a 2nd stage thermostat start up condition, a three minute cooling cycle reset period to allow compressor pressure equalization and the sequential start-up operation for the solar driven Rankine loop. The Rankine engine vapor quality control employs a flow restrictor and a pressure sensor to detect vapor quality limits at the outlet of the Rankine loop vapor generator. The pressure sensor energizes an electronic integrator which provides phase controlled power to an electrically operated valve which regulates bypass flow from the feed pump discharge. In addition, a magnetic sensor is employed to detect expander speed. An electronic circuit provides an over speed signal which also powers the electrically operated feed pump bypass. A second level sensing circuit on the electronic tachometer indicates underspeed operation of the expander. This signal terminates solar cooling and transfers to electric cooling.

The controls breadboard also includes ambient temperature and solar hot water sensors and circuits which are used to provide a "go/no-go" signal for the solar cooling system.

2.3.2.10.2.7 Packaging - Assembly of the Model I S/E DHP test prototype is essentially complete. The LTR assembly is 50% complete with calibration of key LTR components 70% complete. The Model I S/E DHP is planned to be a test bed for controls development, overall system integration and performance evaluation, and for testing new or modified components. The Model I S/E DHP test activities are planned to provide pertinent engineering data common to the S/E DHP and S/E DAC Model II design.

Model II S/E DHP and S/E DAC packaging concepts have been initiated.

Different component and subsystem arrangements are being evaluated in terms of overall performance, size and an ultimate product configuration.

2.4 TEST

Test planning is proceeding at all levels of component, subsystem and system for the heating and cooling configurations.

2.4.1 LOW TEMPERATURE RANKINE COMPONENT TEST LOOPS

Refurbishment of two of the four existing facilities for Low-Temperature Rankine (LTR) component testing is completed. As reported earlier, four complete and separate LTR component test loops will be available on a full-time basis to support the development of the LTR components throughout the life of the program. The two completed loops are designated the "A"-Loop, one 3-ton loop (3A) and one 10-ton loop (10A). Figure 2.4-1 serves as a representative schematic for the 3A or 10A test loops. The 3A test stand provides for mounting the expander with the shaft vertical, the 10A test stand provides for horizontal mounting of the expander.

The "B" test loop, 3B and 10B, are being reconfigured with identical components to the "A" Loops and are scheduled for completion September, 1977. Both "B" test stands will provide for vertical mounting of the expander as shown for the 3A test stand. Schematically, the "B" loops are essentially the same as for the "A" loops. Changes worth noting are the addition of two turbine flow meters in the R11 loop to measure directly lube flow and pump by-pass flow. Learning type changes include valve changes to improve flow setting of the hot and cold water supplies and additional drains to facilitate cleaning of the loops.

2.4.2 HEATING AND COOLING TEST FACILITY

The System Test Facility for the 3-ton and 10-ton heating and cooling systems is shown in Figure 2.4-?. The outdoor cooling tower shown on the left in the figure is in place and the distributor piping to the LTR loops and the 3-ton and 10-ton environmental rooms is presently proceeding on schedule. The 30-ton

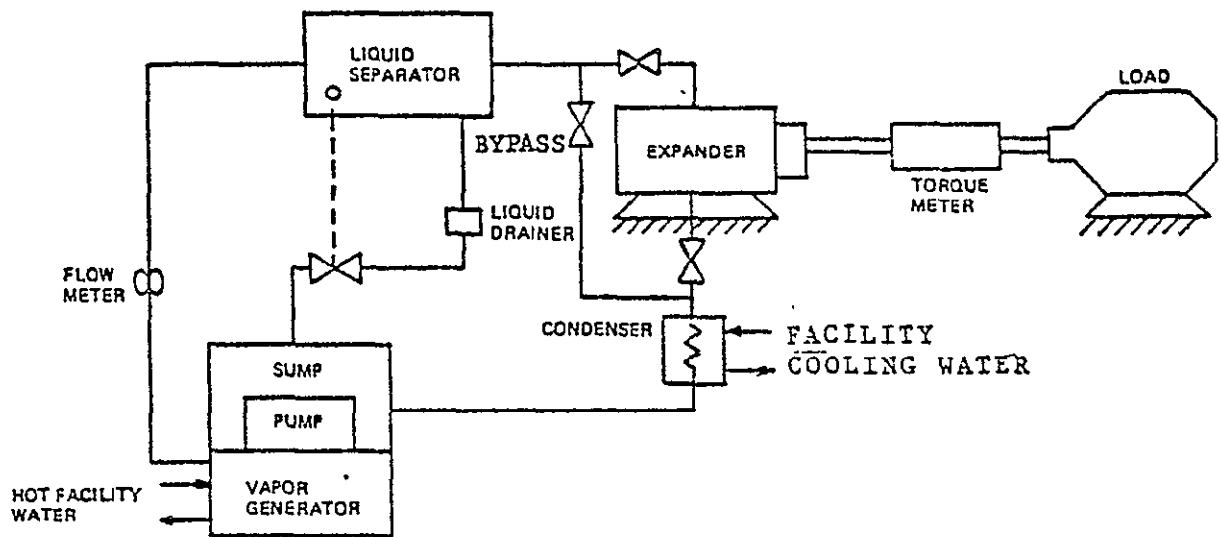


Figure 2.4.-1. LTR Test Loop

mechanical refrigeration chiller, shown schematically below the outdoor cooling tower, will provide controlled cooling to simulate any cooling tower condition to support the four LTR test loops and the two system chambers. The chiller is in place on its mounting pad, and the piping and electrical power installation is proceeding, with check out of the system scheduled for July 15, 1977.

2.4.3 HSF QUALIFICATION TEST

Plans are being finalized for modifying the HSF qualification system to incorporate a horizontal TES tank and representative circulating pumps. Subsequent to making the hardware changes and leak testing the system, qualification testing of the HSF will proceed and follow the previous test plan for the worst case condition.

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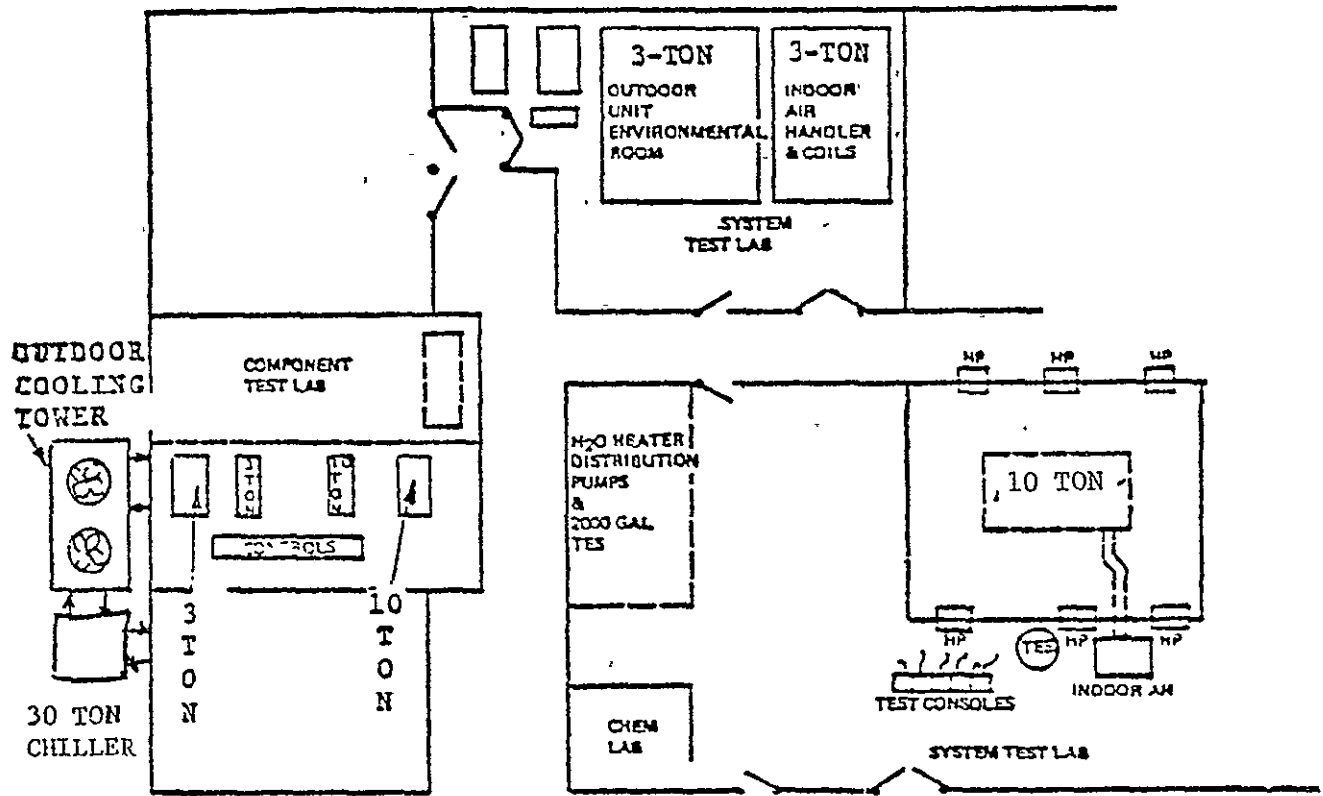


Figure 2.4-4. System Test Facility

SECTION 3

TASK 1.3 - DELIVERABLE HARDWARE

Following the prototype design review and discussions of the RIDs which occurred on May 26, go ahead was received to proceed with ordering hardware for the heating only single family applications. This go ahead did not include activity in the collector glass shrouds because the problems need to be resolved in this area prior to production. Subsequently, the Ft. Meade operational test site was deleted from the program (June 17) and consequently a hold was placed on ordering hardware for one of the residential test sites.

Long lead items for the solar collector hardware have been working at a low level prior to resolution of the glass problems. This activity continued during this period.

The major activity in the deliverable hardware area involved the preparation of material requests and vendor negotiations for the hardware element of the system. Designs of the TES tank and energy module have been finalized and vendor activity on each of these items was initiated. Some difficulty is being experienced with buying standard components to the GE prepared specifications. These difficulties are focused in the area of softwares where ordering small numbers of items is not compatible with other than normal documentation practices. We plan to resolve this problem to move toward procuring hardware as it is done in the heating and cooling industry.

SECTION 4

TASK 1.4 - OPERATIONAL TEST SITES

4.1 SITE IDENTIFICATION

Operational test activities in this period included the identification and inspection of sites selected by NASA/MSFC. Sites that have been investigated are listed in Table 4-1 and those visited during this period are indicated with a dash line. The sites accepted are shown in Table 4-2 along with the dates of acceptance. During this period, the Muscle Shoals site was transferred from the heating only category to the heating and cooling category, and two commercial heating sites were identified. The buildings visited in Los Angeles are characterized by large cooling requirements (smallest was 90 tons) and the use of dual duct systems. Of the three homes visited in Dallas, the two president houses were large and served by more than one cooling system. Only the graduate student housing is a viable candidate.

4.2 SITE DESIGN

4.2.1 ACTIVITY SUMMARY

Work proceeded on the Ft. Meade sites, the Milwaukee, Wisconsin sites, and the Normal, Illinois sites during this period. Comments on the activity of each site follow.

4.2.2 FT. MEADE, MARYLAND HSF-1

Design activity proceeded on this site to the point where the installation drawings were 80% completed. This work was terminated on June 17 when GE was notified by NASA that the site was no longer a candidate. Information supplied was that the landlord (Dept. of Defense) is not participating in this program.

4.2.3 NORMAL, ILLINOIS HSF-2

Design activity on the Normal, Illinois site proceeded during this period. An interface meeting was held between NASA, GE, and the Illinois State University. All indications are that the landlord (ISU) is eager to have the solar system installed and is cooperating to the fullest extent. An architect has been identified and will begin work in the next reporting period. A prototype design review was held at GE Valley Forge on the HSF-2 site at the end of this reporting period.

4.2.4 MILWAUKEE, WISCONSIN HCOM-1

An interface meeting was held at the Martin Luther King site in Milwaukee, Wisconsin. The concept report was completed and transmitted to the site owner. It is anticipated the prototype design review for this site will occur in late July.

4.2.5 MUSCLE SHOALS, ALABAMA

There was no design activity on this heating and cooling site during this period. Up until the time it was converted on April 20 from a heating only site activities were underway. An architect had been selected and was about to begin work.

TABLE 4-1
SITES INSPECTED BY GE

Bldg. Type	General City	Site	
HSF	Baltimore	7502 Young St., Ft. Meade, MD.	
HCOM	Muscle Shoals	TVA Office at Muscle Shoals, AL.	
HMF	Nashville	Airman's Quarters, AEDC, Tullahoma, TN.	
HSF	Peoria	Chanute Air Force Base	
HSF	Peoria	MHA, Champaign, ILL.	
HSF	Peoria	ISU House, Normal, ILL.	
HMF	Schenectady	MHA, Schenectady, NY	
HMF	Schenectady	VA Hospital Staff Housing, Albany	
HMF	Schenectady	Ely Park Housing, Binghamton, NY	
HCMF	Chicago	Ft. Sheridan, ILL	
HCMF	Chicago	Great Lakes Naval Training Center	
<hr/>			
↓ THIS PERIOD	HCOM	Madison	Hill Farm State Office Bldg., Madison, WI
	HCOM	Milwaukee	Washington Park Senior Citizens Center
	HCOM	Milwaukee	Washington Park Community Center
	HCOM	Milwaukee	Dr. Martin Luther King Community Center
	HCOM	Spokane	YWCA
	HCOM	Spokane	East Washington State College
	HCOM	Spokane	Community College
	HCCOM	Los Angeles	West L.A. Municipal Bldg.
	HCCOM	Los Angeles	Dept. of Water & Power #1
	HCCOM	Los Angeles	Dept. of Water & Power #2
	HCCOM	Los Angeles	Peck Park Rec. Bldg.
	HCCOM	Los Angeles	Police Credit Union
	HCSF	Dallas	President's Home, Univ. of Texas at Dallas
	HCSF	Dallas	President's Home, N. Texas State, Denton, Texas
	HCSF	Dallas	Grad Student Housing at SMU

TABLE 4-2
OPERATIONAL TEST SITE STATUS

TYPE	LOCATION	DATE ACCEPTED BY GE	COMMENTS
HSF	Ft. Meade, Md.	Jan 19, 1977	Site deleted on June 17, 1977
HSF	Normal, Illinois	Feb. 7, 1977	
HMF	Tullahoma Tenn.	Feb. 7, 1977	Multi-family units dropped from program verbally on April 4 and documented in minutes of April 4 meeting
HCOM	Muscle Shoals, Alabama	Jan 19, 1977	Converted to Heating and Cooling Site on 4/20/77*
HCOM	Milwaukee, Wisconsin	May 23, 1977	Martin Luther King Community Ctr.
HCOM	Spokane, Washington	July 1, 1977	YWCA
HCSF	Open		
HCSF	Open		
HCCOM	Muscle Shoals, Alabama	April 20, 1977	
HCCOM	Open		

* Design activity was on hold pending this decision.

NOTE: Great Lakes, Illinois was accepted as a HCMF site on Feb 7, 1977.
All multi-family sites have been dropped from the program.

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