DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150571

SCHEDULES, TECHNICAL STATUS, AND PROGRAM ACTIVITIES IN THE DEVELOPMENT OF A SINGLE FAMILY SOLAR SPACE HEATING SYSTEM

Prepared by

Contemporary Systems, Inc.
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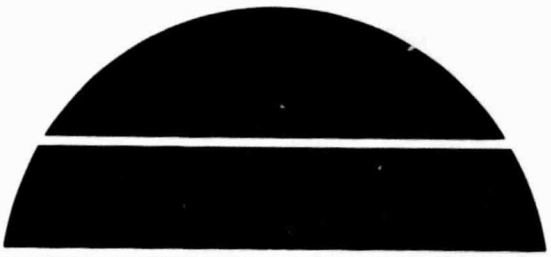
Under Contract NAS8-32243 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



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This work was done under the technical management of Mr. Valmore Fogle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This document is a collection of three quarterly reports from Contemporary Systems, Inc., covering the period from November 1, 1976 through October 13, 1977. Contemporary Systems, under NASA/MSFC Contract NAS8-32243,are developing two prototype solar heating systems consisting of the following subsystems: collector, storage, control, transport, and site data acquisition. The two systems are being installed at York, Pennsylvania, and Manchester, New Hampshire.

This report has been retyped by MSFC for legibility and removal of cost information.

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FIRST QUARTERLY REPORT

I. Summary

This report describes the progress made by Contemporary Systems, Inc. on this contract from October 23, 1976 to February 1, 1977. Part II summarizes the Preliminary Design Review of January 25, Part III describes our progress in our Development and Verification Plans, and Part IV is a bar chart describing our progress to date. All data and top level drawings that we have generated have been previously submitted.

II. Contract

On January 25, 1977, the Preliminary Design Review was conducted at the office of Contemporary Systems, Inc. in Jaffrey, New Hampshire. Val Fogle and Mitch Cash from NASA and Mike Carbone of DCASMA met with John Christopher and Ed Linton of CSI. After a brief tour of our facilities and a viewing of our testing equipment, the meeting started about 9:30 a.m. and covered in order the topics outlined in the PDR agenda.

Included here is a copy of the agenda, notes on the major topics of discussion, and new material presented at the meeting.

Training Program - It was suggested at the meeting, that we add a section under Course #1 to establish precautions and limitations on system installation that will maintain the integrity of the system and retain our independent lab safety certification. We will append the Training Program (type 2) as suggested. We will also use the system manuals in the training courses and will look into the possibility of using only one group of tradespersons to do installation and maintenance of the entire system. Special instructions will be included to exclude the SDAS from the installers and maintenance work. A cost estimate will be submitted on this program.

Logistics - A change order will be submitted, after the operational test sites have been chosen, defining CSI's logistics support through the test heating season. It was pointed out during the meeting that it should include a definition of our responsibilities toward the SDAS and the five year spare parts support.

Hazard Analysis and Materials in Contact with Circulating Air (Heat Transfer Fluid) - It was suggested that we add, to our Hazard Analysis,

consideration of worst case stagnation conditions and failure of our fail safe overtemperature venting. This implies consideration of outgassing from materials in contact with circulating air at higher temperatures. NASA may be able to help us where manufacturers can't provide this information. We will submit an evaluation of all pertinent materials at worst case temperatures. The possibility of fire or toxic fumes from fire entering our system and then the living space was suggested for our consideration. NASA will get us information concerning the possible hazard from use of fiberglass duct board. It was also pointed out that loss of glazing, due to negative wind loading, constitutes a possible system hazard.

System Performance Specification - It was decided that final sizing of the two prototype systems will wait until the sites have been chosen. The final SPS will be submitted, in the form given in Appendix G of the contract, 30 days after the two sites are specified. The purpose and scope of the installation drawings was made clear: to tell the architect and/or builder how to modify the building to accept the solar system.

Quality Assurance Plan - In the discussion of the QA Plan, CSI pointed out that we cannot draw up complete QA procedures and specifications until the systems final configuration has been defined, until we complete development and independent lab certification. Consequently, the final QA Plan due date will be changed to two weeks prior to the Prototype Design Review, and a Technical Directive establishing this is coming. It was also decided that the form of our QA system is left to our discretion, and that the government agent from DCASMA, Mr. Carbone, will not oversee our QA beyond administration of the contract.

UL Testing - NASA has made preliminary contacts with UL regarding safety certification. Mr. C. B. Schram of UL has advised that UL will be willing to perform this service. Safety evaluations will be made on: collectors, from engineering drawings, manufacturers test data. Switching and transport from test configurations and engineering drawings and control components from unit testing and evaluation and engineering data and drawings. The procedure suggested by UL will be a preliminary visit to the manufacturers facility to give preliminary guides as to possible deficiencies. This cost is expected to be about $1600. The following analysis and testing by UL would then be expected to run in the range of $8,000±. UL would be certifying that the systems met the safety standard of the IPC and related codes.

Change requests will be submitted to NASA prior to implementation of the UL program.

Instrumentation Plan: The Preliminary Instrumentation Plan (PIP) was submitted as per TD #1 on 11-23-76. This plan was a total listing of all instrumentation required as per our then existing system configuration. The final version of this plan will be submitted two months prior to PDR on August 3, 1977. The IBM contact relating to the SDAS will be Frank Digesu. NASA will approve the Instrumentation Plan (AIP) one month prior to PDR.

Site Selection - Site selection by NASA has not been finalized at this time. CSI has recommended the use of the proposed Grodin House as one operational test site. This is a new construction designed to accept the solar hardware. It would require no compromises in mechanical systems as do most retrofit jobs. CSI has stated a desire that both projects be new construction. After the selection of test sites, CSI will complete the SPS on forms provided.

AGENDA

Preliminary Design Review

I. Tour of Physical Plant

A. Introduction of staff members
B. Viewing of test equipment and development hardware
C. Explanation and discussion of test program

II. Formal Presentation and Discussion of Documentation and Data Required for Preliminary Design Review

A. Review system and subsystem design and development approaches
B. Drawing review
   1. Drawings required for system definition
   2. Drawings defining baseline system, review
C. Identification of applicable design standards
D. Discussion of system performance specifications
E. Discussion of hazard analysis
F. Selection of data from internal engineering documentation for future design reviews
G. Discussion of data required for prototype design review
H. Verify schedule for prototype design review so as to support delivery schedule
I. Review of Government selected operational test sites
J. Discussion and establishment of a schedule for the "contractor's" completion of the installation drawings
K. Review of site data acquisition system delivery schedule
L. Presentation and discussion relating to type 1, 2 and 3 documents
M. Additions to formal presentation of PDR materials.

III. Discussion of Contract Items not Related to PDR

A. Change Orders
B. Technical Directives
C. Recon system
D. Other items

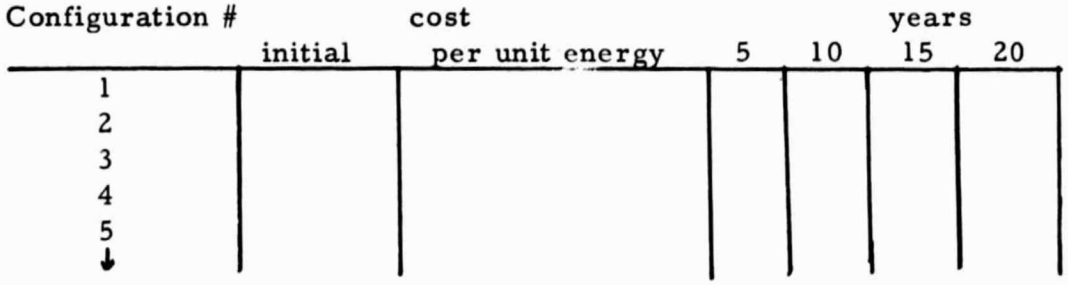
SYSTEM DEVELOPMENT APPROACHES

The following outline describes the approach that will be used in determining system configuration. Life cycle costing will be utilized with emphasis on total cost over the life of the system being the deciding factor as to configuration. Specific economic and performance assumptions will be made and will be identified.

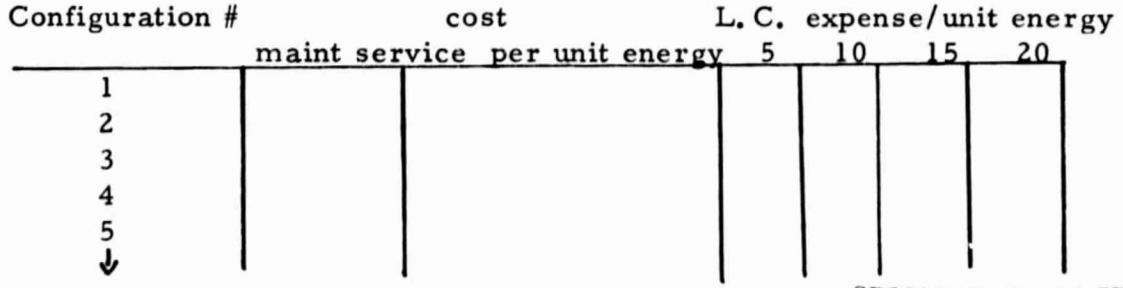
The methodology described is general and will occasionally involve choices made on judgement rather than quantified data. This is due to factors which involve convenience to the installer/user and accepted method vs. new technology. These non-quantifiable variables will be noted.

The process will be repetitive as desirable configurations are selected and combined.

1. System first cost
   - A. Does cost of system minimization have higher priority than maximizing energy capture?
   - B. Comparison between total system configuration and its first cost with energy delivered/unit cost
   - C. Life cycle first cost data: 5, 10, 15, 20 years



2. Minimize: maintenance, repair and replacement expense
   - A. Compare maintenance and service expenses with cost/unit energy delivered between different system configurations
   - B. Express configuration expenses as they relate to cost/unit energy delivered
   - C. Express data as function of life cycle cost



3. System operation expense
   A. Analysis of operating expense of systems, the major expense being heat transport
   B. System configurations compared with operating expenses per uni' energy delivered
   C. Express operating expense as a function of life cycle cost

Configuration #	operating expense/ expense	expense/ unit energy	L. C. expense/unit energy 5	10	15	20
1						
2						
3						
4						
5						
↓						

Selection Procedure:

1. Select configurations which provide most favorable life cycle cost/unit energy delivered, as in system first cost table.

2. Select configurations which provide most favorable L. C. maintenance costs/unit energy delivered.

3. Select favorable operational cost configuration.

4. Determine composite configurations with most favorable L. C. costs.

5. Select optimum for system configuration.

Note: Items one and three have the largest effect on total L. C. cost, allow a broad base for systems comparisons.

Applicable Design Standards

1. System Performance Specification, Contemporary Systems Inc.

   Our SPS constitutes the basic design standard which CSI is using during system development and verification.

2. Interim Performance Criteria for Solar Heating ..., HUD and NBS

   The IPC is the major standard referenced by the SPS, and the sections which are applicable to our system are defined in the SPS. Other documents are in turn referenced by the IPC, among them are:

3. HUD Minimum Property Standards, One and Two Family Dwellings (No. 4900.1), HUD

4. Building Code Requirements for Minimum Design Loads in Buildings and Other Structures, ANSI A58.1-1972

5. Uniform Building Code, International Conference of Building Officials

These are the current industry design standards for solar heating systems. Any deviation from these will be noted and detailed by Contemporary Systems, Inc.

III. Schedules

A. Development Plan

1. Test Equipment - The volumetric air flow measuring unit and the air reconditioning apparatus have been completed and integrated into the collector test bed. The test bed has been outfitted with preliminary instrumentation and is now in use.

The Eppley precision pyronometer and the Robinson-Halpern very low air pressure transducer have been ordered and received. The Kaye Instruments Digistrip Transmitter Analog/Digital (and thermocouple) converter and thermocouple wire are on order. This final instrumentation package will soon be mounted on the collector test bed.

The data acquisition and processing system has been chosen after careful study. A Data General Nova 3 minicomputer system is now on order. Climatic data is being ordered from the National Climatic Center, Asheville, NC, and software development is underway.

With the equipment, the preliminary testing is underway and full testing capability will be realized before the end of March.

2. a. Collector thermal development - Thermal development of the collector subsystem is continuing. Efficiency testing is ongoing and preliminary results have been submitted in the preliminary System Performance Specification.

b. In the collector mechanical package we have implemented the extruded aluminum side rails and an improved end cap design. Structural standards have been obtained and their requirements are being derived. Our preliminary structural tests on the existing collector configuration indicate we will have no problem complying with the standards for roof and wall loading. Delivery of a new aluminum extrusion for the glazing system fastening is expected soon.

3. Air Transport and Switching Development - The Universal Switching System has been redesigned from a two piece system into the one piece Universal Switching Unit. A prototype is now being assembled.

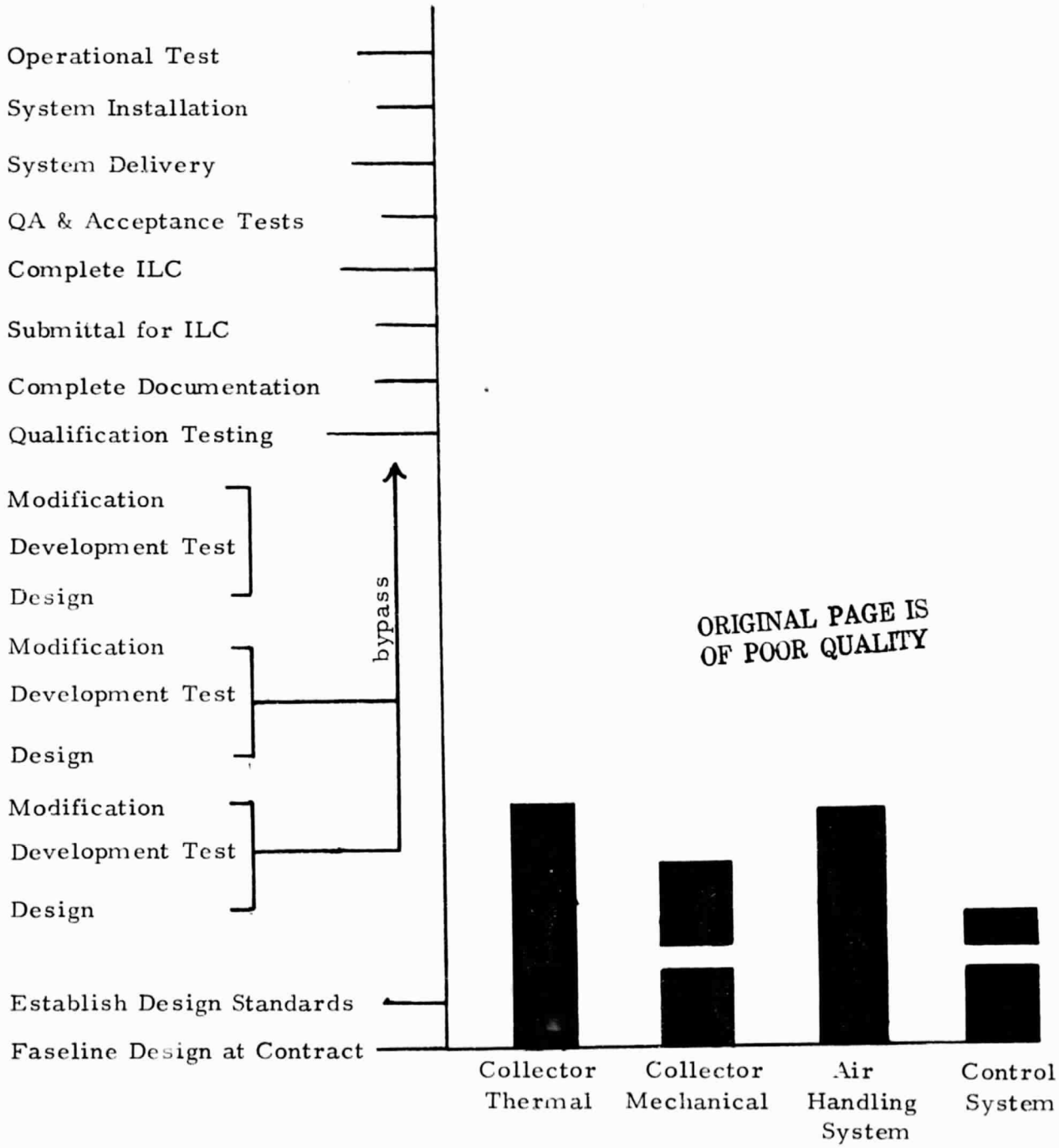
General Electric and Buffalo Forge are working closely with CSI on the design of our efficient air handling package.

4. The LCU-100 control system is evolving into the LCU-110, a universal control for the new USU based solar system and other air circulating solar systems. Design specifications are being established with the help of Underwriters Labs. This development program has been delayed temporarily, but we foresee no scheduling problems. This increase in design time will allow us to incorporate UL's design standards and coordinate their independent lab certification.

B. Verification Plan

All subsystems are currently in the development phase. The current progress of each subsystem is as represented above under development plan.

IV. Technical Performance as of February 1, 1977



SECOND QUARTERLY REPORT

I. Summary

This report provides a description of progress on NASA contract NAS8-32243 during the period from February 1, 1977 through May 1, 1977.

It begins with a synopsis of the material covered at the Second Quarterly Review. This is followed by a summary of the work actually accomplished during this period on the Development and Verification plans, including a bar chart illustrating this progress. All relevant data, drawings and test results generated during this time have previously been submitted.

II. This section has been deleted due to cost information.

III. System Development Status

A. Collector, thermal:

During this second quarterly period the collector performance testing program has continued and is now nearing completion. Various design configurations have been tested and the results analyzed in terms of cost vs. performance. The design changes have been incorporated into a deliverable prototype which is now undergoing final testing. Full documentation on the final system will follow shortly.

B. Collector, mechanical:

Considerable effort has gone into mechanical design revisions during this time. A new extruded aluminum side clip has been designed and incorporated as part of the glazing assembly. The end cap configuration has gone through two design modifications. An integral side rail insulation system is currently being analyzed for cost-effectiveness, and if it qualifies complete drawings and specifications will be forthcoming. There have also been several modifications of the absorber plate design since the first Quarterly Review, and a mounting system which allows for differential thermal expansion has been chosen.

C. Air transport and switching:

Two prototype units have been assembled during this quarter, and one is presently installed in a working system where its performance has been quite satisfactory. The second unit is presently being prepared for both

performance and cycling tests and a loss coefficient will be determined for the switching system. The results of these tests will be available before the Prototype Design Review.

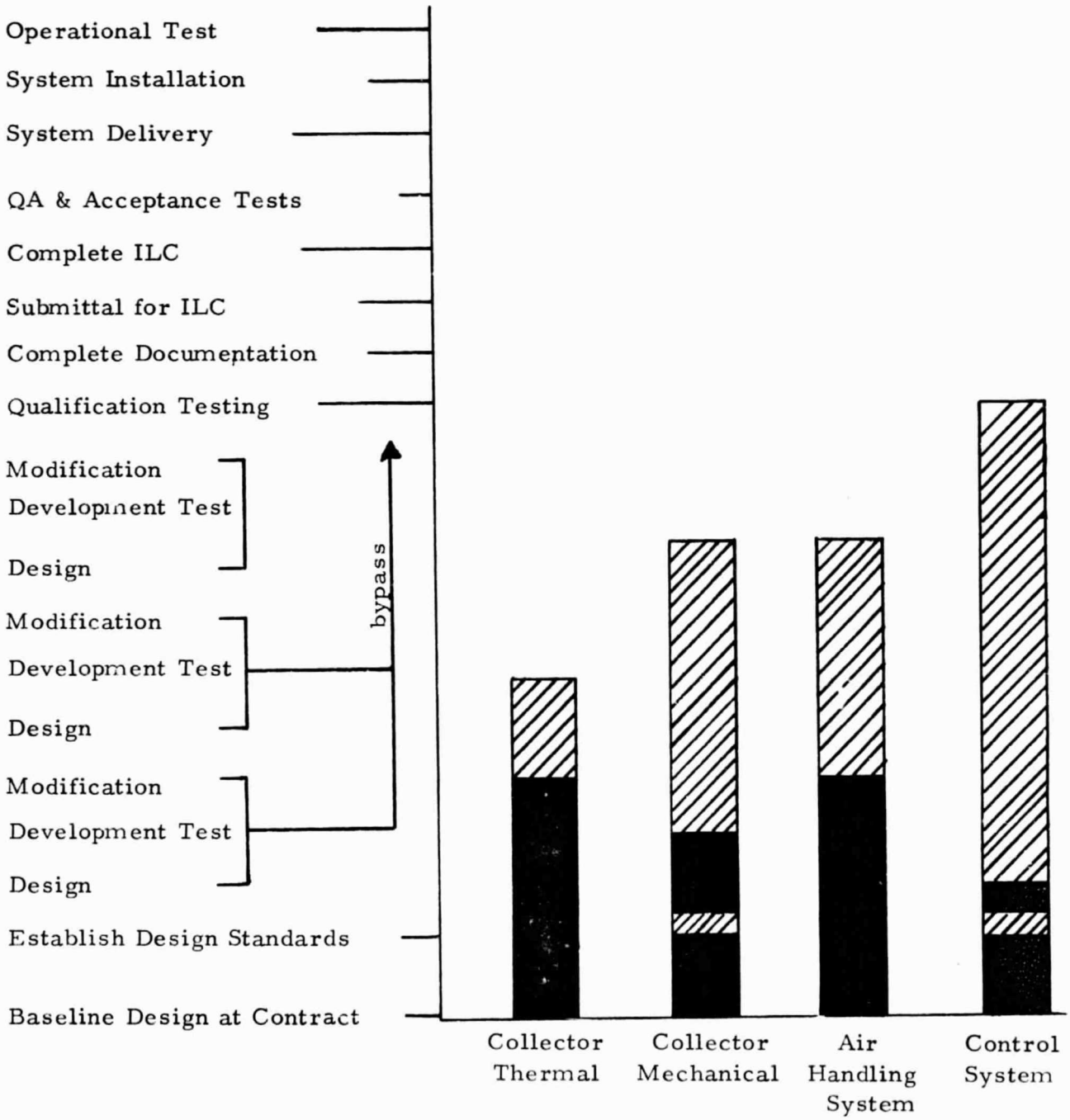
D. LCU-110 Logic Control Unit:

As previous noted, it was during this period that the control unit was redesigned from the original LCU-100. The new prototype has been assembled and qualification testing completed. The design changes have allowed for an improved interface with conventional heating systems and have met IPC and UL specifications.

E. Thermal vents:

The fail-safe thermal venting unit prototype has been constructed and will be tested under simulated power failure conditions.

IV. Technical Performance



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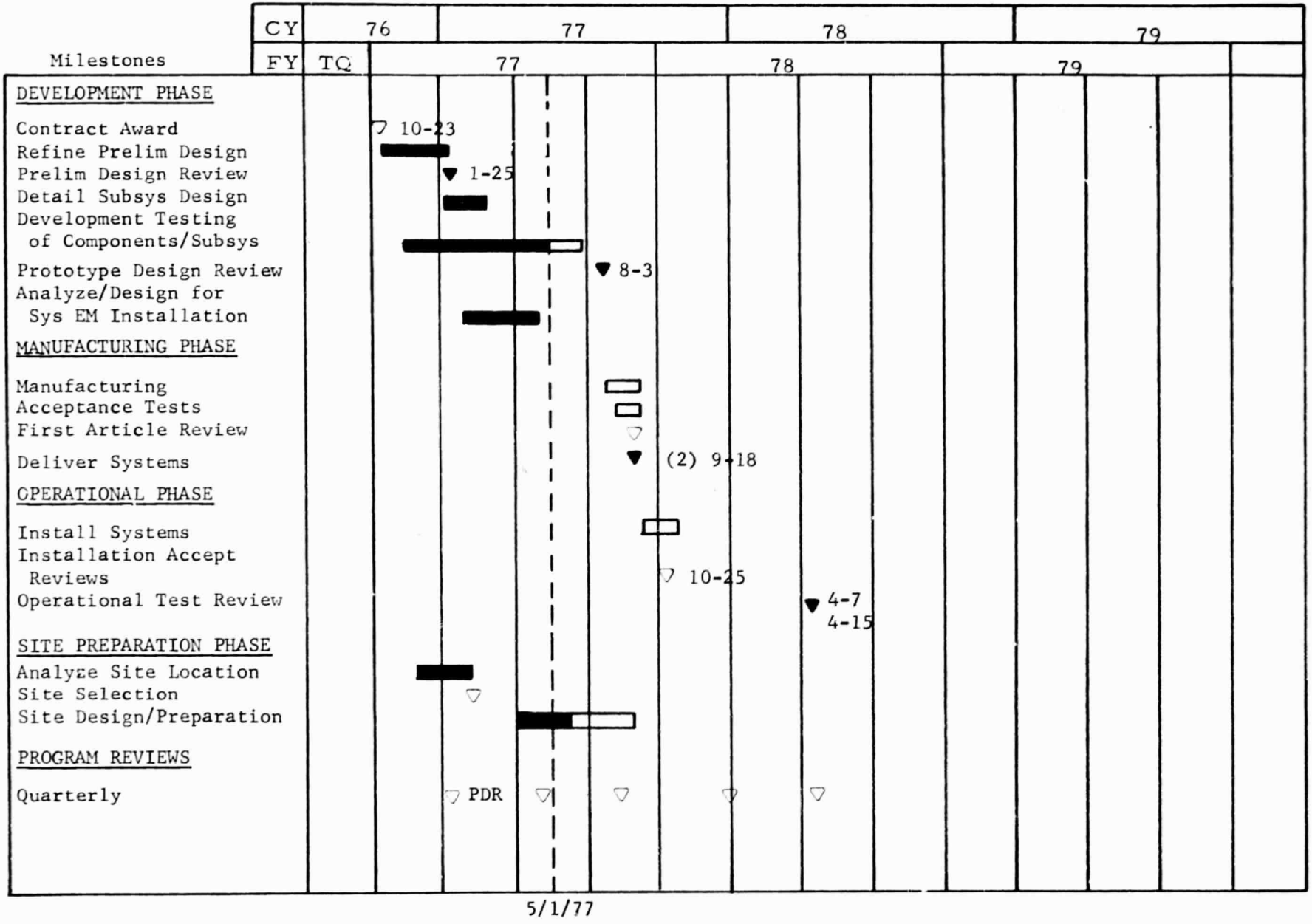


First Article Review Summary

The meeting was attended by Ed Linton and John Christopher of Contemporary Systems, Inc. and Val Fogle of NASA/MSFC. CSI opened the meeting with a presentation of the current design of its Series V. Solar Heating System.

Drawings submitted as top level include:

120-008	200-017	500-014
130-010	200-019	540-003
150-006	200-021	510-005
130-017	200-016	510-002
130-016	200-020	500-013
100-004	230-004	560-001
	210-005	540-002
400-009	200-022	520-001
410-008	200-023	530-001
410-011	200-024	500-012
430-004	230-003	
430-006		910-002
410-013		910-001
		900-001
		900-002

Additional information on collector materials needed by NASA was defined and will be sent along with a complete set of LCU-110 drawings.

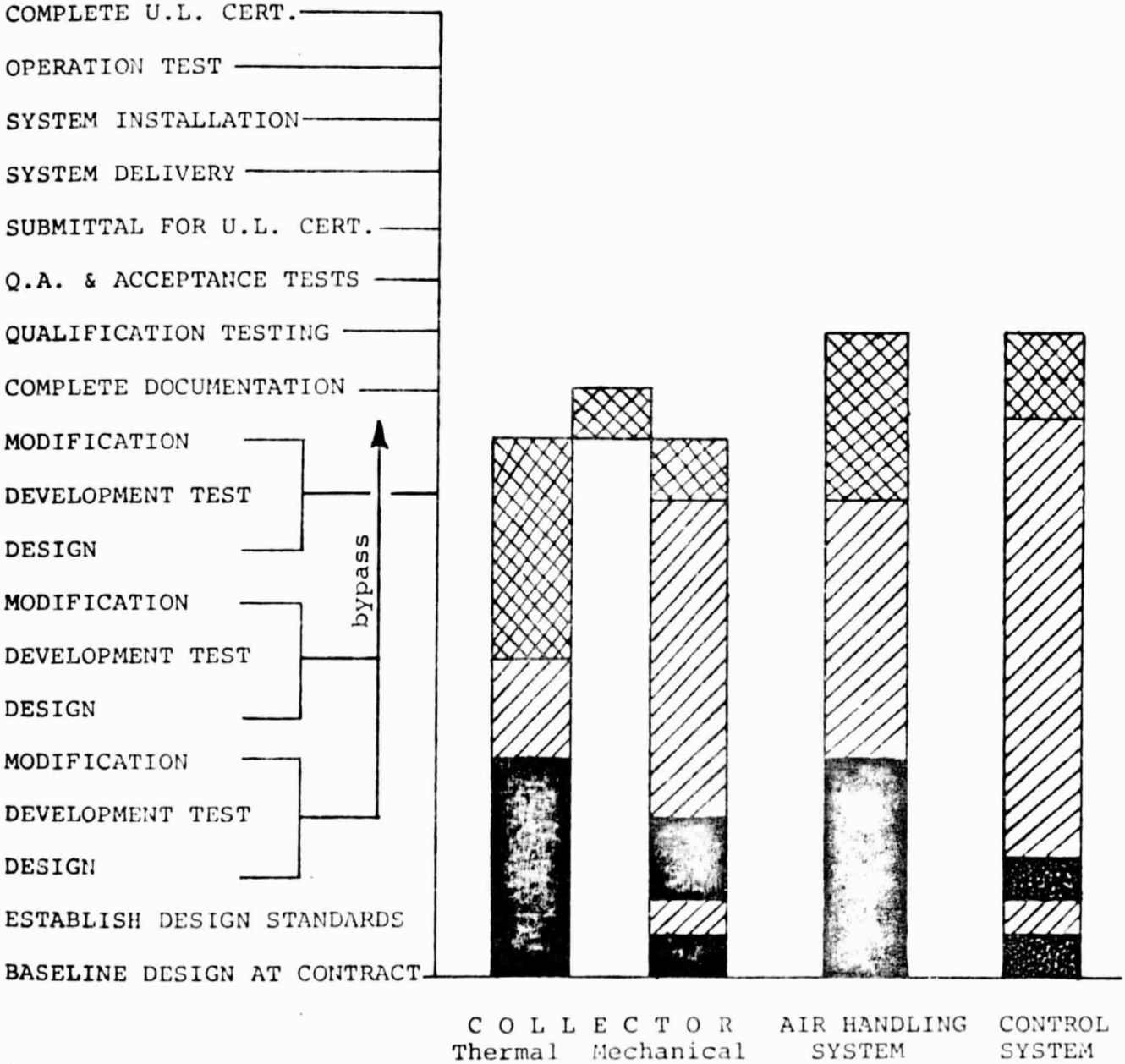
The instrumentation plan for the Manchester site was discussed and has been baselined. Details on the SDAS installation were noted. It was decided that the probes will be shipped to CSI in Jaffrey.

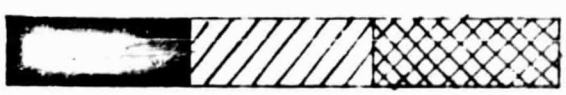
The CSI Installation, Operation and Maintenance Manual and Design Data Brochure were reviewed. The Job Specification Sheet enclosures will be drawn up for the Manchester and York sites and will be presented at the Installation Acceptance Review.

Schedules for system and SDAS installation and startup for the Manchester and York sites were brought up to date and are included with this report.

After lunch the group toured the CSI production facility and viewed components in progress. Progress on the NASA/NHVTC project has been delayed as a result of a late extrusion delivery; however no delay in scheduled delivery is expected. After a tour of the production facility the group visited a recent CSI installation at the Winchendon Savings Bank in Massachusetts. The meeting adjourned at approximately 4:45 p.m.

Technical Performance





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